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CONTENTS

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Review Article

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Geographic Information Systems for Egyptian Agricultural land evaluation

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ABSTRACT
Evaluating the Egyptian agricultural lands in terms of their capability and suitability for cultivation with different crops is necessary to reach the best benefit. Therefore, many researchers and specialists in the field of land evaluation follow several methodologies and apply different models to reach the most accurate results. Among those used methods, mathematical and statistical models are deal with many layers of data. On the other hand, computerized and automated models developed by software packages save time, effort and deal with a huge amount of data at one time. One of the most important tools currently used in presenting the results of land evaluation is the Geographic Information System (GIS) tools. These tools deal with spatial and soil attributes in the multiple sites to be evaluated. The main advantages of these tools are that they display data over a wide geographical scale in the form of spatial distribution maps. These maps are very important for decision makers in achieving better agricultural practices and optimal utilization of land resources. With the use of these tools, future planning for reclamation and cultivation of lands becomes clear and simple, in addition to saving costs significantly.
Keywords: GIS, Egypt, Land Evaluation

INTRODUCTION

Continuous agricultural lands evaluation for the purpose of maximizing their use is very necessary. Especially at the present time, good planning is mandatory to achieve the optimal utilization of all environmental resources. Many agricultural lands around the world are exposed due to major problems such as desertification, urban sprawl, degradation, pollution, and others. With the continuous climatic changes causing a change in the conditions of agricultural production in those areas, it was necessary to discuss the issue of continuous agricultural land evaluation. It is difficult to conduct continuous evaluation of agricultural lands for a particular area using traditional methods. These conventional routine methods require time, effort and cost, in addition to the inaccuracy in some cases. Therefore, it is necessary to use modern methods and models that can match soil spatial and attributes' data to conduct the evaluation on a wider geographical scale. Based on these reasons, GIS has proven highly efficiency in producing spatial distribution maps for different land uses, as well as evaluating agricultural lands and classify their data into different orders and classes. Moreover, Ibrahim et al. (2013) mentioned that the integration of GIS and remote sensing was found to be an effective tool for sustainable land use planning. Sayed and Khalafalla (2021) concluded that GIS technique with geostatistical tools is a valuable approach for capability and suitability evaluation of land. For land suitability evaluation, there many layers of data related to soil parameters, climatic conditions, social and environmental impacts of a specific land use that planned to be evaluated. However, land suitability evaluation includes questions of (where, why and when) the crops grow (Sekiyama and Nagashima 2019). To answer these questions, many different methods of land suitability analysis are followed. That meant, there is no universal or a standard methodology or a protocol for this process. The main output of the process of land suitability analysis is to judge the land (Suitable or unsuitable) for specific use. With these data, possibility to answer questions (when and why) will be there. Using these outputs, land suitability mapping using different spatial variability distribution and geostatistical analysis can be used to answer the question (where) depending on spatial and soil attributes (Mugiyo et al., 2021). Because of big data included in the evaluation, Multi-Criteria Evaluation (MCE) is used. Therefore, Geographical Information Systems (GIS) found to be an effective approach for land evaluation. It is capable to investigate multiple geospatial data. Moreover, integration of remote sensing, GIS, and machine learning techniques could enhance the accuracy and the predictability of land evaluations' outputs. Decision-makers must have a sufficient knowledge about land evaluation used techniques whereas many factors should be included in

the applied criteria. Not only soil attributes are used, but also climate data as well as socio-economic factors should be included in the criteria of land evaluation (Atoyebi et al., 2017). In Egypt, with the dramatic increasing of population and with agricultural land challenges such as urban sprawl, salinization, degradation and climate change, land evaluation should be done for better agricultural management.

Therefore, and based on what has been mentioned previously - the aim of this review is to clarify the importance of modern methods, especially geographic information systems, in evaluating land globally, and to know the extent of its application on Egyptian lands.

Land Evaluation

Land evaluation is considered as a tool for systematic and strategic land-use planning for a specific purpose. Moreover, it can be expressed as a knowledge-based that requires different conditions to be included and achieved. Land evaluation can be automatically done by the use of different models such as agricultural land evaluation system (ALES), land evaluation for capability (LECS) and geographic information system (GIS) as Ganzorig and Adyasuren (1995) description. Evaluation of land is an interpretation of the soil attributes, cropping cover, climatic conditions and other data layers related to the specific purpose of land-use to characterize and diagnose the optimal land-use among these alternatives (Sayed, 2006). Therefore, using a suitable approach to deal with these multiple data layers is needed. Geographic information system (GIS) is an important tool for land evaluation mapping and these outputs can be utilized for sustainable planning of land resources (George, 2015). Land evaluation is also the process of assessing land performance for specific purposes or to estimate and predict the use of land (van Diepen et al., 1991). Agricultural land evaluation includes two major types (capability and suitability evaluation). For the agricultural lands in Egypt, the situation is difficult because of many challenges that face the Egyptian Government. The increase of population and urban sprawl on the Nile Valley agricultural lands are the main problems. Furthermore, climate change is a vital factor controls the sustainability especially for agricultural sector in Egypt. Food security is targeted from the government to achieve better life for Egyptian people. Therefore, agricultural land evaluation is strongly needed for better utilization of lands and for achieving optimal income.

Land Capability

Land capability could be defined as the use of the land in specified way or management practices (Dent and Young, 1981). Land capability classes refer to the use of a piece of land for a targeted reason such as building, cropping, woodland, or wildlife (Mohamed, 2002). Capability class means the degree of goodness for land-use (For example, Agricultural activities). These classes can be subdivided into sub-classes based on limitations or conservation required. Manikandan et al. (2013) explained that these subclasses present limitations of the land under evaluation (such as erosion hazards, stones, shallowness, salinity, low fertility, excess water, and climatic limitations). Land capability could be includes in four classes (excellent, good, moderate, and not capable). There is a big number of studies were carried out regarding agricultural land evaluation either for capability or suitability evaluation in Egypt. These studies used several techniques and followed different approaches for agricultural land evaluation. There are methodologies depend on soil data only, while others used multiple evaluation criteria whereas soil attributes integrated with climatic data, socio-economic factors' data as well as spatial information. Many of previous studies done for agricultural lands' evaluation in Egypt depend on using GIS techniques and tools combined with machine learning and geostatistical analysis. These studies proved that the integration of remote sensing, GIS, and soil multiple layers were found to be as an important tool for land evaluation.

Land Suitability

Land suitability classification aims to fit the land for a specific use. Land suitability evaluation is based on soil survey; socio-economic information and the aim of land-use. There are two main suitability orders (suitable and non-suitable). Suitability classes refer to land limitations and they are (highly suitable, moderately suitable and marginally suitable). Moreover, classes are divided to sub-classes vary in management requirements (Manikandan et al., 2013). Elnaggar (2017) defined Land suitability as how the land is fitted with the requirements of a specific target of the land-use either in actual land-use or after improvement as estimated potential suitability. Moreover, it is a matching between land attributes and crop requirements to estimate land quality for a spcific land use (Mustafa et al., 2011). There are many studies done in Egypt for evaluating land suitability and capability. For Example, in El-Dakhla Oasis, Ibrahim et al. (2013) evaluated land capability and suitability for different 16 crops where a part of the area was having a good capability while other parts was under fair capability condition. They also found that the study area was moderately suitable for cultivating Alfalfa, Olive, Mango, groundnut, potato, wheat, and Sorghum while highly suitable for Barley. They used remote sensing and GIS tools for mapping their results successfully. Abosafia et al. (2022) found that GIS tools capable to evaluate the capability and suitability of Kafr El-Sheikh soils whereas they used ASLE model for evaluation. Their results indicated that, the land varied between very poor and fair capability. They also found that the land was highly suitable for wheat, barley and date palm, moderately suitable for growing Maize, and not suitable for Onion and Citrus.

Soil Fertility

Soil fertility evaluation is a part of land capability evaluation but for specific physico-chemical properties. Soil fertility was defined by Food and Agricultural Organization (FAO) as ability of soil to sustain of required nutrients by growing crops in sufficient

quantities and correct utilities (Jin et al., 2011). Fertility status of the soil is the most important component that control the productivity potentials which strongly influenced by management activities (Johnson et al., 2000). Moreover, nutrient index (available P, available K and OC) and the soil reaction index are used for evaluation. With these inputs, soil fertility is evaluated under different classes (poor, medium and high) fertility (Abah and Petja 2015).

Agricultural Lands' Evaluation

Many decisions makers resort to evaluating agricultural lands to see how productive their lands are and also to make a decision about which crop is best grown on those lands. For example, in Egyptian agricultural lands, Fayed (2003) evaluated the land capability of El-Bostan region, West Nile Delta and classified it to moderate and marginal capability classes. the main limiting soil factors in the studied soils were soil texture, ESP, salinity and calcium carbonate content. Abd El-Khalek (2004) applied the soil capability index to Wadi El-Rayan soils and matched between the soil properties and rating of Storie index. He found that a half of investigated lands were non-agricultural while the other half is varied between poor and excellent soils. Some soils of Wadi El-Natrun area was studied using remote sensing and GIS techniques whereas FAO framework of land evaluation was applied Abd Al-Hamid et al. (2010). They pointed out that the study area was classified for capability to be under three classes (moderately suitable, whereas topography, soil texture and salinity were the limiting factors; temporary not suitable and permanently not suitable). They also estimated the potential capability of the land and their finding revealed that the limitations could be removed by enhancing some soil properties and the land could be cultivated with five main crops (wheat, barley, grapes, alfalfa and fodder beet). Mahmoud et al. (2009) used agricultural land evaluation system (ALES) for evaluating land capability in some Egyptian soils. They found that the current capability of the area ranged between high capability and moderate capability classes. After enhancement of soil parameters, soil could be moderately suitable for cultivating maize, olive, figs, wheat, sorghum and barley. They recommended using of GIS combined with modeling approaches for capability evaluation.

Some Used Methodologies and Models For Land Evaluation

For estimation of actual and potential land productivity, Riquier et al. (1970) approach is used. In this method, nine factors were considered for determining soil productivity, soil moisture content (H), drainage (D), depth (P), texture (T), soluble salts content (S), average nutrient content (N), organic matter content (O), soil cationic exchange capacity (A) and reserves of weatherable minerals (M). Each factor is rated on a scale from 0 to 100 and the actual percentages are multiplied by each other to calculate the productivity index (PI). The resultant index for productivity, also lying between 0 and 100, is set against a scale placing the soil in one or other of five productivity classes, namely excellent, good, average, poor, and extremely poor. The potentiality index (P\I) for the future land productivity estimation is also calculated after improving characterizations which considered as limitations of productivity.

Regarding evaluation and classification of land capability, several methods and approaches are applied. The most common used methods are Requier (1970), Storie index (1954), and Sys and Verheye (1975). Capability methods of evaluation depend on soil data (physical, chemical, and fertility) parameters. In some other methodologies, the climate data are also used as input data layer in the used model of evaluation.

The Sys et al. (1993) model is a parametric method which commonly utilized because of its comprehensiveness and ease of application. The Agricultural Land Suitability Evaluation (ALES) model (Ismail et al., 2001) has proven to be very fast, efficient, and easy for using.

The Storie index (Storie, 1954) is a mathematical model which can match many soil factors such as soil profile (A), the texture of surface soil (B), and a miscellaneous land factor including drainage, slope, and alkalinity (C). In addition, factor X can be considered related to miscellaneous soil parameters that can be modified by management. These parameters are nutrients status, alkali status, pH-level, soil erosion, and micro-relief. Each factor is scored as a percentage but multiplied as a decimal. The final index is expressed as a percentage. Where more than one property is considered, as in factor X, each is also scored as a percentage, and then all are multiplied together as decimals and expressed as the combined percentage of that factor. Soil grades of Storie Index were presented in table (1).

Sys and Verheye (1975) proposed the capability index (Ci) based on nine parameters for crop production in the arid and semi-arid regions (A: soil texture, B: calcium carbonate, C: gypsum, D: salinity, E: sodium saturation, F: drainage, G: soil depth, H: weathering stage, and I: profile development). Each factor is scored as a percentage but multiplied as a decimal. The final index is expressed as a percentage. Sys (1976) proposed the following scheme (table.2) for evaluating the degree of limitation. The limitation approach has been successfully used to provide a qualitative land evaluation based on general characteristics that are made available after a quality soil survey and general study of other soil resources in the area.

The parametric method was proposed by Sys et al. (1991); whereas soil-site parameters considered for land suitability evaluation are climatic data (i.e. available moisture or precipitation, temperature, and relative humidity), morphological characteristics of the soil profile (i.e. soil depth, slope, flooding, drainage and erosion level), Physical condition of the soil (i.e. soil texture, gravels, and Stoniness), and chemical parameters of soil (i.e. calcium carbonate, nutrient availability, gypsum, organic matter, cation exchange

capacity, base saturation, salinity, alkalinity, and sodicity). Table (3) showed suitability classes and limitations of soils.

The Agricultural Land Evaluation of Suitability (ALES) model was developed by Ismail et al. (2001); whereas depe nds on using multi-criteria for evaluating the suitability of land. The same soil-site parameters mentioned above were used in the ALES model.

Geographic Information System (GIS)

A geographic information system (GIS) is an information system that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially-reference data, as well as a set of operations for working with data. In a sense, a GIS may be thought of as a higher order map (Azad, 2009). It is a powerful tool for data handling, processing and management, and solving environmental problems, but tools can do nothing without methods. (Panigrahy et al., 2006).

Importance of GIS

For such projects of agricultural land evaluation, huge number of soil samples should be collected and analyzed. In addition, a lot of effort is given for surveying and data collection. Therefore, fast and accurate technique should be found to be as an alternative for the conventional methods of soil surveying, sampling and analysis. For that, GIS is a cost-effective tool savings labor and analysis costs by about 75%. Routine methods are not able to get spatial data for all studied locations, but GIS is helpful for providing this data. GIS products such as mapping of soil properties as well as the land situation and classification of capability and suitability are considered as greatly assist for decision makers. These outputs can be easily shared among different teams, work-groups, departments, organizations, and all people. The main importance of GIS is visualizing the outputs in a larger geographic scale without extra cost. Furthermore, the integration of soil attributes, spatial data, machine learning algorithms, GIS and remote sensing is very necessary for getting an accurate situation for un-surveyed locations.

Components of GIS

The GIS environment consists mainly of Hardware, software, data, users and methodologies. Hardware includes laptop or computer system which GIS software packages run. These devices must be in a suitable condition to be matched with the used software. Some computers are connected with a scanner to scan a paper map and convert it to digitized one as in image format (TIFF, BMP, JPG etc.). The printers used as output device for a GIS work. The GIS software are used for their tools to store, analyze, and display data. Examples for GIS software are (MapInfo, ArcInfo, ArcView, ArcMap, etc.). There is free sourced software such as QGIS. Spatial data is other component of GIS used for generating soil maps. GIS users are technical specialists, operators, engineers or users.

Applications of GIS in Agriculture

Using GIS tools depend on the spatial data and target attributes. GIS is used in agricultural studies for detecting nutrient which can help in site specific nutrient management, reduce the cost of fertilization as well as increase nutrient use efficiency (Shanmugapriya et al., 2019). By application of some useful models such as NDVI integrated with remotely sensed data, Buttar et al. (2017) could map the healthy and non-healthy grown plants using GIS tools. Remote sensing and GIS tools of soil and crop can be an attractive alternative to the traditional methods of field scouting because of the capability of covering large areas rapidly and repeatedly providing spatial and temporal information necessary for sustainable soil and crop management (Basso et al., 2004).

Applications of GIS In Evaluating Some Egyptian Soils

There are many studies which carried out in Egyptian lands for different purposes using GIS tools. Among them, Darwish et al. (2006) evaluated Farafra Oasis soils as one of the newly reclaimed areas in Egypt using microleis model. They could classify land suitability to (highly suitable for wheat, potato and sunflower; and low suitable lands) with limitations of salinity, sodium saturation and texture. They also could map their results using GIS tools. Abdel Rahman et al. (2017) studied sixty soil profiles for land evaluation assessment purpose. They found that the soil could be classified depending on soil characteristics and physiographic units of the area. Their findings revealed that GIS generated maps of the study area could be categorized into several suitability classes. Shalaby and Moghanm (2015) studied the urban sprawl using GIS tools in Nile Delta. They showed that, a wide expansion of urban area on the account of fertile soils occurred during the study period 1984–2006. They could successfully utilized GIS for mapping their findings. Gad (2015) created a land resources database for Dakhla Oasis that aims to assess and map land capabilities based on FAO methodology. The researcher used soil attributed, remotely sensed satellite images, and climate and landscape data as layers of GIS model to classify land capability to (highly, moderately and non-capable soils). He mentioned that the use of GIS and Automated Land Evaluation System (ALES) is very useful to assess land capability and crop suitability. Belal et al. (2014) studied land degradation using GIS data. They demonstrated that about a half of the study area has undergone very high risk, whereas the rest area was under low risk of chemical degradation. Mahmoud et al. (2009) reported that the combination of GIS with modeling approaches such as ALES model is a quite evident proves the power of these tools for decision making in evaluating agricultural lands. Regarding land suitability evaluation, Belal et al. (2014) demonstrated that four land capability orders for agricultural land reclamation (i.e. good, moderate, weak and marginal) were found. Moreover, the evaluation model gives four limiting factors (topography, soils, erosion risks and

bioclimatic deficiency). The researchers could map their results using GIS tools. Moursy et al. (2020) mentioned that the integration of soil surveying, sampling, laboratory analysis, and GIS technique found to be an effective tool for producing spatial information as well as land productivity data. Moreover, these data can be utilized for better land use management, planning for new lands reclamation, and enhancing agricultural productivity. Sayed and Khalafallah (2021) evaluated and mapped land capability and suitability in some parts of Assiut using ASLE and microLIES models. They could diagnose the soil limitations in the study area. El-Sayed et al. (2020) used geostatistical analysis tool in GIS to evaluate and map some soils in Sohag whereas they found that the study area included four capability classes ranged between Good, Fair, Poor and Non-agricultural lands.

GIS Mapping of Soil

Producing soil maps is absolutely essential. The importance of maps lies in the fact that they are a guide for decision makers and workers in agricultural lands to ensure a good use of these lands. Soil mapping depends on digital terrain model (DTM) to construct relation between landform and soil. Field work and laboratory analysis with special reference to soil constrains were the main targets to reach land evaluation and land suitability goals. Land capability and suitability maps are confirmed with the mapping units on the physiographic map for producing the productivity map using several automated models such as microLIES, ALSE, ALES and others. For example, ALES is used in arid and semi-arid regions to estimate the agriculture land evaluation whereas it is linked directly to its relational database and coupled indirectly with a GIS through the loosely coupled strategy.

There is a continuing demand for accurate and up-to date land use/land cover information for any kind of sustainable development program where land use/land cover serves as one of the major input criteria. As a result, the importance of properly mapping land use/land cover and its change as well as updating it through time has been acknowledged by various research workers for decision making activities; as for example, application of land cover change in urban environment by Deng et al., (2005).

Many researchers applied such mentioned models for evaluating agricultural lands in Egypt. For example, Moursy et al. (2020) used GIS tools to map land evaluation classes of Eastern part of Sohag, Egypt. They found that the investigated area was divided to six mapping units viz, Wad floor, Low elevated sand sheet, High elevated sand sheet, Table land, Bajada and Piedmont. Other study was conducted to generate soil maps of landuse/landcover of the soils adjacent to El-Manzala Lake east of the Nile Delta, Egypt using remote sensing and GIS tools. This area was found to be classified into flood plain, the lacustrine plain, and the marine plain. GIS could map the Water bodies and urban areas in the investigated area (Ali and Kotb 2010). The main physiographic units for some promising areas of El- Farafra Oasis. The physiographic point of view, the landscapes include two units (i.e. Plateau and depression floor) as described by Abdellatif et al., 2020. Yossif and Ebied (2016) measured the area of each land use in their study area using Arc-GIS software. Also they mapped the Change detection in the cultivated land area, Fish farms, and reclaimed areas. They could also evaluate the capability of the investigated area for the mentioned several land uses. Yousif (2018) applied GIS tools on the data of El-Tina plain soils to study land degradation between 2006 – 2014 periods. He found that the reason of land degradation is salinity caused by the rise of ground water level to < 50 cm from surface soil. However, he also used GIS tools to evaluate the investigated area where was classified into five main landforms (i.e. Piedmont, Foot Slope, Back Slope, Summit and Escarpment). In the same study, Yousif (2018) evaluated land capability by the modified Stori index. He reported that the studied soils were categorized in to grade 1, grade 2, grade 3, and grade 4 but grade 3 and 4 are the most common. According to land suitability assessment, the most suitable crops in the study area are alfalfa watermelon, barley, wheat, sorghum and olives. The evaluation results indicate that the main limiting factors for agriculture soil suitability in the studied area were soil texture, shallow soil depth, excess of salts and lime. Capability and suitability maps were generated using GIS tools. El-Sayed et al. (2020) successfully mapped capability and suitability of soils in Sohag using GIS-Geostatistical model while Sayed and Khalafalla (2021) recommended the same procedure for mapping land evaluation results. Abosafia et al. (2022) could map their outputs of land evaluation models for some parts of Kafr-Elsheikh using GIS tools.

CONCLUSION

From the review study, it became clear that GIS is very important and necessary in agricultural land assessment. The maps produced by GIS tools are considered as a guide for decision makers and planners for the optimal use of agricultural lands. Geographical information systems have proven highly efficient and competent in evaluating agricultural lands in Egypt. Therefore, it is strongly recommended to use GIS in evaluating agricultural lands in terms of their capability and suitability for cultivation with different crops.

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Review Article

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Polyhydroxybutyrates (PHBs): an eco-friendly alternative to petroleum-based plastics for diminution of their detrimental effects on the environment

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ABSTRACT
Human has been known to use different types of polymers in their daily routine for ages, among which plastics that are derived from fossil fuels or petroleum occupies a greater part. The domestic, as well as commercial use of plastics, has been known so far globally. Plastics are used for packaging, making utensils, household items, portable machines, spare parts, medical stents, spectacles, sportswear, cellphones, golf balls and many other items. Despite knowing the negative and fatalistic effects of plastics, we humans have become dependent on plastics for our daily routine welfare. The major reasons for this are durability, inertness, lightweight, thermal and electrical insulation, resilience to corrosion and readily moulding into multifarious shapes. But the non-biodegradability of this polymer has led to many environmental issues that have detrimental effects. So there is a need to switch from non-biodegradable plastics to biodegradable ones to reduce these harmful effects without the replacement of other properties of *petroleum-based* plastics that makes it one of the most commercially used polymer. Biodegradable plastics have gained a lot of attention over a shorter period. These include Polyhydroxybutyrates (PHBs) and Polyhydroxyalkanoates (PHAs) majorly. These are biodegradable along with all the properties that petroleum-derived plastics have which makes them a finer and eco-friendly option. The present review focuses majorly on PHBs and summarises their physical properties, biosynthesis and different methods of industrial production, extraction, PHB-based biocomposites and/or nanocomposites along with their applications and prospects.
Keywords: Plastics, Biodegradable plastics, PHBs, PHAs, biocomposites, nanocomposites.

INTRODUCTION

Humans consume enormous amounts of polymers in the form of plastics daily. (Lee *et al.,* 2021). Plastics are used widely throughout many industries and have practically become necessary, yet their ever-increasing use has negative environmental effects (Vlaeminck *et al.,*2022). Globally, people are becoming more and more conscious of the negative effects that excessive use of plastic materials in daily life has on the environment and human health. (Sirohi *et al.,* 2021) Traditionally, ethylene and propylene products derived as functional derivatives from fossil hydrocarbons have served as the foundation for the monomers utilised in the wide synthesis of polymers. (Anjana *et al.,*2021). Single-use plastics (SUPs) are materials made from fossil fuels that are often used in the food, beverage, and agriculture industries and are intended to be thrown away right away after usage. It has historically been difficult to recycle plastics, which are frequently made of polypropylene, polystyrene, or polyethene, and present garbage collection systems are unable to securely and properly dispose of our recycled waste material on a worldwide scale. Therefore, these SUPs that sweep up in landfills gradually enter our ecosystems, seas, and food chain, adding to society's escalating issues with plastic pollution (Eriksen *et al.,*2014, Chen *et al.,*2021). By 2023, it is anticipated that demand for these biomaterials would increase to 9.45 million tonnes, which will encourage people to use less synthetic polymers and create biopolymers in a sustainable and circular fashion instead. (Herrara *et al.,*2021).

Recycling is done in certain circumstances to reduce these disposal issues because plastics cannot degrade; nevertheless, this is not a good solution. (Das *et al.,*2021) Only 26% of the 33 billion tonnes of plastics manufactured globally are expected to have been recycled by 2050, according to the latest estimates. (Hernandez *et al.,* 2021) The total amount of production in 2019 was around 360 million tones. (Ryan 2015) Since many polymers are derived from crude oil, the rising demand for plastics not only increases oil consumption, placing additional stress on depleting reserves but also pollutes the environment during disposal (more than 302 million tonnes of plastic were

wasted in 2017) due to the typically challenging and drawn-out process of degradation of these materials and their composites. (Schlebrowski *et al.,* 2021) The creation of fully biodegradable plastics and the switch to them is critical to minimize the increasing pollution brought on by our usage of plastics. (Hernandez *et al.,* 2021) Due to society's and governments' concern for the environment, the use of biopolymers as environmentally benign materials to replace conventional polymers has garnered attention. Polyhydroxybutyrate's (PHB) ability to biodegrade makes it a superior option for substituting petroleum-based polymers. One of the primary challenges to PHB's success in the polymers industry is that they are significantly more expensive than traditional polymers. (Ortriz *et al.,* 2020). The alternate strategy is to select carbon substrates that are sustainable, economically advantageous, and easily accessible for maximal PHB production. Agricultural waste products provide both reasonable carbon and nitrogen sources, which significantly lowers the cost of producing PHB (Brodjnak *et al.,* 2016). PHAs can be utilised in biocomposite materials, which combine bio-based agro-residues, to cut costs while retaining performance in certain industries, such as agriculture, food, and medicine. According to Menossi et al. (2021), bio-based composites are described as composite materials made of two or more separate biodegradable phases. These phases typically include a continuous weak matrix and embedded reinforcements that provide strength and stiffness. The advantages of PHA-based biocomposites strongly support future studies in this field. There is an urgent need to produce biodegradable biopolymer-based bio-composites that may be utilised as a coating material for food packaging. This paper provides an in-depth analysis of PHA blending, which is more effective in enhancing its properties and resulting in better production and higher quality-based usage (Kumar *et al.,* 2021).

Polyhydroxybutyrate

Biopolymers are made from biological materials, are biodegradable, or have both of these properties. The most promising polymers for providing a comprehensive sustainable replacement for plastic packaging are biopolymers. The most sustainable group includes polyhydroxyalkanoates (PHAs), which are both biobased and biodegradable. (Gracia *et al.,* 2022) To address the environmental problems caused by nondegradable plastics, PHAs have been suggested as a partial replacement for conventional petrochemical plastics like polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET) (Tan *et al.,* 2021). The bacterial strain, carbon feedstock, and growth conditions utilised all affect the monomer structure and physicochemical characteristics of the various PHAs. Currently, it is known that there are more than 150 distinct PHA monomers, with 3-hydroxybutyrate (3HB) and 3-hydroxy valerate (3HV) being the two most prevalent (Gracia *et al.,*2022). French scientist Maurice Lemoigne characterises poly-hydroxybutyrate (PHB) for the first time in 1923 (Yeo *et al.,* 2018).

Many prokaryotes produce this highly crystalline, biodegradable, linear polyester as lipid stores at times of impending stress, such as when there is an abundance of carbon sources available and no other nutrients, such as nitrogen, oxygen, sulphur, phosphorus, etc (Thapa *et al.,* 2019).

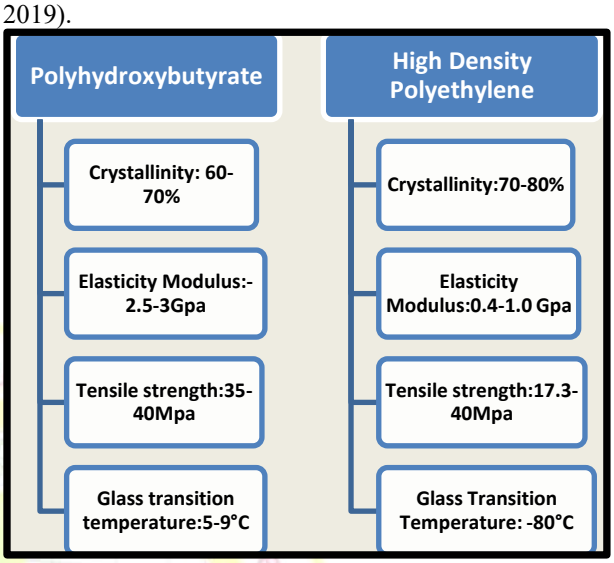

Fig.1. Comparison of physical characteristics of Polyhydroxybutyrate and High-density Polyethylene

Unlike traditional polymers, biodegradable polyhydroxybutyrate (PHB) does not release any hazardous residues into the environment. It may be produced using industries based on agricultural and hydrolyzed polysaccharide waste (Sirohi *et al.,* 2020). Agriculture waste can be used as a potential substrate for the microbial production of polyhydroxybutyrate. A variety of pretreatment procedures must be used to break down the complex chemicals in the agricultural leftovers so that PHB-producing organisms may use them as a substrate. Agro waste can be pre-treated in various ways to make simple sugars and fatty acids easily available for effective microbial consumption. For instance, it has been claimed that PHB is produced by whey, starch, oils, legumes, sugar refineries, and other lignocellulosic wastes.

It may be produced utilising a two-stage cultivation technique that includes fermentation and extraction. The separation of PHB biopolymer occurs during fermentation using carbon sources as fructose, glucose, xylose, etc (Manikandan *et al.,* 2020). The microbial strains *Bacillus megaterium*, *Cupriavidus necator*, *Ralstonia eutropha, Pseudomonas aeruginosa*, *Aspergillus*, *Penicillium*, etc. are some examples of those that frequently produce PHB. Due to their biodegradability, biocompatibility, and nontoxicity, PHB has several uses in nanotechnology, healthcare, the food industry, and agriculture.

Polyhydroxybutyrate and high-density polyethylene are similar in terms of their physical characteristics, such as

crystallinity, tensile strength, melting temperature, and water vapour permeability (Figure1). PHB has excellent resistance to moisture while being stiff and rather brittle. The chiral monomer unit of PHB exhibits a high degree of polymerization and is insoluble in water. PHB is a semi-crystalline polymer whose melting properties fall between between those of crystalline and amorphous materials. When pure cultures are used to make PHB, a high PHB yield of more than 80% cell dry mass is obtained (CDM). (Pradhan *et al.,* 2018)

Biosynthesis of PHB:

The biosynthetic reaction of PHB occurs only on the granule's surface. The intracellular mediation of acetyl-CoA regulates the formation of acetoacetyl-CoA reductase (Figure 2). The pool of free CoASH is increased under non-nutrient-restricted growth conditions during the exponential growth phase. However, when growth is limited by nutrients, such as phosphate or ammonium, PHB synthesis is encouraged.

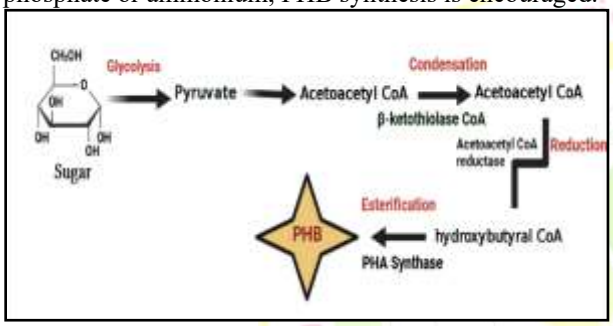

Fig.2. Biosynthesis of PHB

Industrial Production of Polyhydroxybutyrate:

PHB materials can be produced by many different bacterial strains, with reports stating that more than 300 different bacterial strains are known PHB producers. Despite these intriguing properties, industrial production of biopolymers, particularly PHB, is still in its early stages. W.R. Grace Co. of North America made the first commercial attempt to produce PHB in the 1950s. However, due to low production efficiency and a lack of a suitable purification method, this process was not successful. Polyhydroxybutyrate is a available as Biomer commercially. However, commercial production was halted due to the high production costs compared to oil-derived plastics. This cost comes from the complex production process that includes several steps such as selection of the raw material, bioreaction, separation and drying of the biomass, PHB extraction, and processing. (Gast *et al.,* 2022). To commercialise PHB, significant efforts have been made to reduce production costs through the development of bacterial strains and more efficient fermentation/recovery processes (Figure 3). According to the literature, the major cost in this biopolymer production is the cost of the substrate which accounts for more than 50% of the production cost and causes the price of poly-3-hydroxybutyrate (P3HB) from Biomer to be about 12 times that of polypropylene. To address this issue, microorganisms for PHB production are fed inexpensive substrate, renewable substrates and waste material because it provides the dual benefits of utilising waste and producing biodegradable microbial bioplastic at a low cost. (Bhuwal *et al.,*2013)

PHB can be made by mixing different substrates under various growth circumstances, including aerobic and anaerobic growth, temperature and pH change, submerged or solid-state fermentation, and combining several substrates.

Some Bacillus species accumulated PHB at a rate of roughly 55.6% when utilising pre-treated sugar stick bagasse as a carbon source and 51.6% while using maize cob. When pea cell slurry (biowaste) was employed as the carbon source, PHB production was found between 945 and 1205 mg/L (55-65% w/w). A total of 435 mg/L (31-62% w/w of total cell dry weight (CDW) of PHB was produced from glucose. (Getachew and Woldensibt, 2016)

A bacterial cell's buildup of PHB is a vital survival mechanism in response to stress. Numerous bacteria have been studied for their ability to accumulate PHB, including *Bacillus cereus, B. subtilis, Alcaligenes eutrophus* [Hahn *et al.,*1995], *Escherichia coli, Pseudomonas putida* [Castro *et al.,*2013]*, Rhodococcus sp. NCIMB 40126, Rhodococcus rhodochrous ATCC 19070* [Haywood *et al.,* 1991], *Cupriavidus necator* up to 40–50% of the dry weight of the cell is accumulated PHB. There have been reports of Alcaligenes eutrophus accumulating up to 96% PHB of the cell dry weight (CDW) (Anjana *et al.,* 2021).

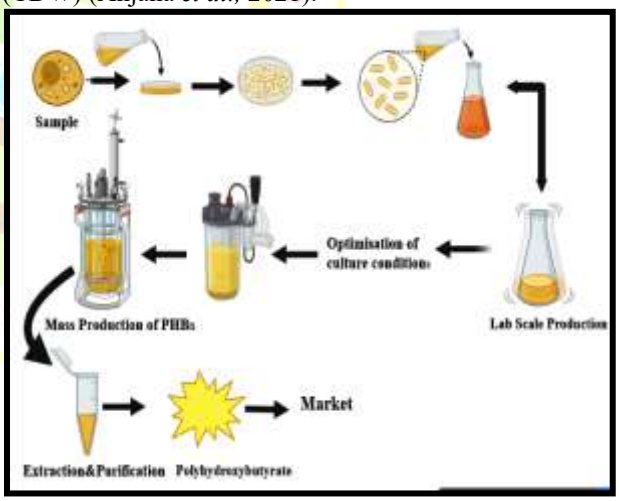

Fig.3. Industrial Production of Polyhydroxybutyrate

Different methods of PHB Extraction

One of the difficult downstream processes to make bioplastics from microorganisms is PHB extraction. There are many basic chemical extraction techniques for PHB from bacterial cell mass; they all involve three crucial steps: harvesting cell pre-treatment, polymer extraction, and post-treatment purification. Solvent extraction, chemical surfactant digestion, sodium hypochlorite, sequential surfactant hypochlorite, enzymatic digestion, and bioextraction are used to extract polymers from PHB. The yield for solvent

extraction in various strains with different solvents varied from 45 to 96%, whereas the purity of the PHB varied across procedures from 45 to 99% (for chemical digestion surfactant) and 86% to 99% (for LAS-99).

Due to its simplicity and speed, solvent extraction is a routine technique in many laboratories. PHB is dissolved in a range of organic solvents, such as 1,2-dichloroethane, chloroform, cyclohexanone, and 1,2-propylene carbonate, during the second part of the procedure. The first step entails increasing the permeability of the whole cell membrane to make PHB accessible. (Haddadi *et al.,*2019) non-solvent precipitation in methanol and ethanol is the method used to separate the PHB solvent.

In the surfactant technique of chemical digestion, the cell membrane is damaged because the production of micelles by surfactant integration allows for the exposure of carbonosomes and the dispersion of PHBs and cell debris into the lysis solvent pool. Other techniques like sodium hypochlorite, sequential surfactant hypochlorite, and sodium bisulfite are frequently employed, although they have significant drawbacks. For example, a lower molecular weight can be produced by utilising chemical digesting surfactants such SDS, Triton X-100, betaine and sodium bisulfite.

Moreover, chemical digestion surfactant accompanied by chelate has been used to improve PHB purity. Since enzyme digestion is an environmentally friendly method with mild operating conditions for PHB recovery. Proteolytic enzymes like proteases and glycosidases have also been considered for an increase in purity without environmental drawback but with high-cost drawback and high specific activity.

The toxic reagents are needed for PHB extraction procedures such solvent extraction and chemical digestion surfactant, which also cause significant quantitative and qualitative environmental and economic losses. Biological extraction techniques are receiving increased attention for PHB extraction because of their favourable characteristics. Though these issues have not yet been resolved, they can be lessened by using more biotechnological approaches in bioextraction techniques such as the Cell engineering is often combined with the alteration of culture conditions and feedstocks in order to get around limitations of conventional approaches.

It is essential to have a firm understanding of bioextraction methods in order to build targeted green technology solutions for very pure PHB extraction with eco-friendly features. (Haddadi *et al.,*2019) Additionally, due to their extraction potential (especially intra-carbonosome PHB) during self-disruption and predatory digestion, bioextraction systems, including those associated with bacteriophages, predatory systems, and mealworm digestive systems, are attracting a lot of interest (Figure 4). With less detrimental effects on the environment and human health than previous methods, PHB bioextraction employing green technology may be preferred.

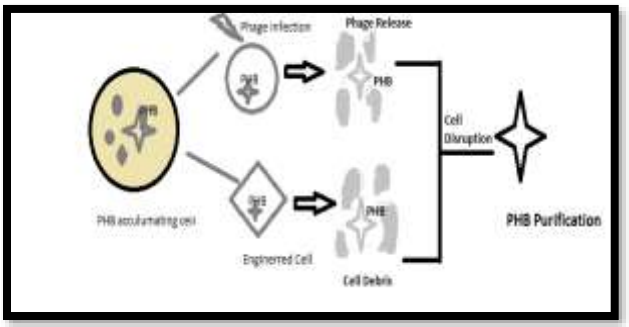

Fig.4. Bacteriophage lysis system of PHB

PHB based biocomposites:

By overcoming its inherent constraints, the creation of biodegradable PHB-based biocomposites with enhanced mechanical qualities might lead to the opening of new doors for industrial applications. As a result, nanotechnology is a very promising area of research for the twenty-first century and is essential for the extensive rebuilding of novel applications in the field of biotechnology. (Pande and Sanklecha, 2017). The modernization, creation of more ecofriendly products, and development of more effective procedures have greatly improved today's quality of life. Exploiting resources that are sustainable and renewable is necessary to fight this expanding tendency. It is a simple, cost-effective, and environmentally friendly process to produce gold, silver, and platinum metal nanoparticles by microbial synthesis. (Kavitha *et al.,* 2018) Based on a number of factors, green technology produces nanoparticles that are much better than those made through physical and chemical processes. Green methods, for instance, don't utilise costly chemicals, use less energy, and create products and byproducts that are safe for the environment. (Patra and Beck, 2014) PHA's structural characteristics enable the creation of nano-sized PHA pellets that come in a variety of forms and sizes. This opportunity expands the potential applications for PHA as a nanocomposite. Another type of materials known as bionanocomposites are nanocomposites made of naturally occurring polymers (biopolymers) combined with inorganic nanoentities (BNCs). Compression, extrusion, moulding, and injection are some of the several processes used to create biocomposites. (Raza *et al.,* 2019) Their nanocomposites were designed to increase the PHB's toughness. According to studies, PHB nanocomposites of various compositions shown improved physical characteristics with an increase in the rate of elongation range of roughly 5-80% as comparison to 2% for neat PHB. (Kavitha *et al.,* 2018)

An efficient method for producing biopolymers with enhanced characteristics is the mixing of PHA polymers. The parent polymer's limits are restricted by blending. PHB blends have drawn interest because they improve the physical and mechanical characteristics of PHBs. PHBs mix with organic polymers including starch, cellulose, and lignin. (Tripathi *et al.,*2021). Therefore,

PHB must be combined with other substances or biopolymers to produce new PHB-based biocomposites with added value. PHB has been incorporated with different biomaterials (or biopolymers) several times in an effort to create sustainable biocomposites. For instance, PHB's brittleness is reduced by combining it with other substances to create unique biocomposites including PHB/poly (ethylene glycol) (PEG), PHB/cellulose, PHB/starch, and PHB/chitosan. Novel biocomposites should be tangible to a variety of forms, including particles, fibres, mouldings, films, membranes, foams, and coatings. (Raza *et al.,* 2019)

PHB/cellulose: In order to retain the crystalline character of cellulose fibres, the structure of cellulose comprises hydroxyl groups for inter and intra hydrogen bonding between glucopyranose units. (Raza *et al.,*2019) PHBs are incorporated with appealing polymers called cellulose derivatives. For instance, cellulose propionate, cellulose acetate butyrate, and ethylcellulose are frequently utilised as a PHB blend. (Tripathi *et al.,* 2019). Cellulose derivatives help PHB break down and are compatible with it. Hydrogen bonding within the cellulose molecules is what gives the material its high modulus (138 GPa) and tensile strength (18GPa). These characteristics allow for the incorporation of cellulose into PHB to create biocomposite materials. (Raza *et al.,* 2019) Wei and colleagues (2015) used a dicumyl peroxide-based extrusion technique to graft PHB onto the cellulose fibres. Efficiency of grafting was influenced by concentration and reaction time. The degree of crystallinity was decreased in both the amorphous and crystalline portions of the PHB and cellulose as a result of the grafting mechanism. Smaller PHB crystals also decreased the brittleness of the material. PHB and cellulose grafted copolymers were more stable than ungrafted PHB and cellulose. The created bio-composite could be applied to packaging and other things. To create a bionanocomposite based on PHB and cellulose nanocrystals, Seoane and colleagues (2015) employed the solution casting method (CNCs). They noticed that CNCs in the PHB matrix have the best features for nucleation. According to the study, as CNC concentration increased, so did Young's modulus and tensile strength. When compared to pure PHB, the produced bionanocomposites showed reduced water vapour permeability, and they also showed better UV barrier characteristics (propylene). Potential uses for the created composite include packaging. In a different work, Seoane et al. (2016) used solvent casting and compression moulding to create biodegradable bilayer composites based on PHB and cellulose cardboard. Due to the hydrophobic PHB solution penetrating the hydrophilic cellulose cardboard fibres, compression moulded composites experienced more moisture absorption than composites created using the solvent casting approach. As a continuous layer of PHB was generated on the composites created by compression moulding, they showed better mechanical characteristics than the composites created by solvent casting made of cellulose, cardboard. Due to the hydrophobic PHB solution penetrating the hydrophilic cellulose cardboard fibres, compression moulded composites experienced more moisture absorption than composites prepared using the solvent casting approach. As a continuous layer of PHB was generated on the cellulose-based cardboard, the composites created by compression moulding displayed better mechanical characteristics than those created using solvent casting. The produced composites were used in the agriculture and food packaging industries.

PHB/Starch: Since starch is naturally biodegradable, it is frequently utilized as a natural polymer. Because PHB is compatible with starch, production costs are reduced and the product's qualities are improved. The PHB-starch mixture had a single glass transition temperature and a 30:70% higher tensile strength than PHB. (Tripathi *et al.,*2021). The food packaging industry can use this mixed PHB film as a coating material. PHB-based starch biocomposites had been developed using a variety of methods. The methods being thought about enhanced the thermal and mechanical characteristics of PHB, which encouraged totally biodegradable composites. Through the use of the melt compounding approach, Zhang and Thomas (2009) created composite blends of starch and PHB that included the two substances in a 70:30 weight percent ratio. They noticed that hydrogen bonds formed between the carbonyl group of PHB and the hydroxyl group of starch, preventing PHB's chain scission degradation and enhancing the composite's temperature stability. Melt mixing and heat pressing were used to create PHB-based starch composites, according to Lai, 1995 and colleagues (2006). After adding water and glycerol as plasticizers, the starch granules were distributed throughout the PHB matrix using the gelatinization process. According to the study, increasing glycerol level boosted weight loss and water absorption, but increasing PHB content had the opposite effect. In a mix of soluble potato starch and PHB, they found that weight loss and water absorption were 30.3% and 70.9%, respectively.

PHB/ Hydroxyapatite: Wet chemical precipitation, biomimetic deposition, or electrodeposition are all ways to make HA. Calcium phosphate, which has strong osteoconductivity, bioactivity, biocompatibility, high stiffness, and low elasticity, forms the basis of the HA structure. Some HA mediated PHB composites had been produced for dental and orthopaedic implants in order to enhance their mechanical properties. Using compression moulding, Shishatskaya et al. (2006) created a hybrid composite made of PHB and HA. Surface wettability, interface energy, and cohesive forces all improved as HA content in the composites increased. According to Zhuo et al. (2010) HA and PHB were created using hot pressing and ball milling. By utilising silane as a coupling agent to form covalent bonds with both the HA and the PHB, the interface of the HA/PHB composite was enhanced. The developed biocomposite might be

employed in bone tissue engineering as a fracture fixation material.

PHB/Chitosan: Chitin, the main component of crustacean aquatic creatures' exoskeletons, is deacetylated to produce chitosan, a cationic polysaccharide. Since chitosan has so many desirable qualities, including reactivity, biodegradability, natural origin, and availability, it may be used in a wide range of industries, including waste and water treatment, medicine, biotechnology, and manufacturing. (Saini *et al.,* 2017) By using the precipitation process, Chen et al. (2020) created the composite consisting of chitosan, PHB, and maleated PHB. Crystallinity, T_m, and H_m of the produced composite reduced when chitosan content was increased. The PHB/chitosan (80:20) composite had T_m and H_m values of 171.6 C and 87.1 J/g on DSC analysis, as opposed to the maleated PHB/chitosan composite. Emulsion-blending and porous PHB/chitosan scaffolds were created by Cao et al. (2005) using PHB/chitosan composite films. When PHB concentration was increased, the elastic modulus and swelling capacity of the films reduced from 141.1±5.9 to 119.3±4.3% and 8.7 ± 1.6 to 4.9 ± 0.6 MPa, respectively. The study found that when compared to native chitosan films, PHB/chitosan films had a lower elastic modulus but a greater tensile strength.

Starch, cellulose, chitosan, and HA are the most crucial chemical moieties to make biocomposite with PHB for potential relevance in food packaging and biomedical applications, it can be concluded after studying all of the aforementioned biocomposites (Table 1)

Table 1. lists various techniques for creating nanocomposite for usage in the food and healthcare industries.

Nanocomposite	Method of fabrication	Obtained characteristics	Applications
PHB /Cellulose	Extrusion based graft technique	Lessen brittleness and crystallization	Food Packaging
PHB/ CNCs	Casting Solution	Increased Tensile strength and Young's Modulus	Food Packaging
PHB /Hydroxy apatite	Compression moulding	Lower decomposition temperature, Higher crystallinity	Artifical Bone tissue
PHB /Starch	Melt compounding	Thermal stability high	Packaging
PHB /Chitosan	Precipitation Technique	Increased T_m and H_m	Tissue engineering

Applications of PHB based composite

Nanocomposites have several advantages, including cheap cost, high accessibility, ease of fabrication, low density, high transparency, good flow, improved surface characteristics, and flammability resistance. (Motaung *et al.,* 2018) Because of their unique qualities, these materials have drawn the attention of both industrial and educational institutions, including medical, cosmetics, agriculture, and food sectors. Recent developments in PHB-based composites open up new possibilities for applications in health, food packaging, and agriculture.

Agriculture:

To maintain healthy soil structure, moisture retention, and weed control, mulching is a crucial agricultural technique. The mulch films were created using MirelTM PHB and NodaxTM P(3HB-co-3HHx) (Boey *et al.,* 2021). Due to the demand for eco-friendly materials, the depletion of natural resources, and increased awareness of environmental issues, agricultural biomass products are increasingly being used and applied in the development of polymer nanocomposites. Smart polymeric systems have significantly benefited the agricultural industry by improving the efficacy of pesticides, herbicides, and fertilisers by supporting controlled release systems and so enabling the use of lower dosages. (Sikder *et al.,* 2021) A sustainable agriculture delivery system should include the following desirable characteristics:

regulate agrochemical release at the appropriate dose,

safeguard the agrochemical from deteriorating conditions such as light and pH.

have lower cytotoxicity than traditional insecticides

the nanocarriers' long-term validity, which will lower the frequency of pesticide application and treatment by increasing their lifetime.

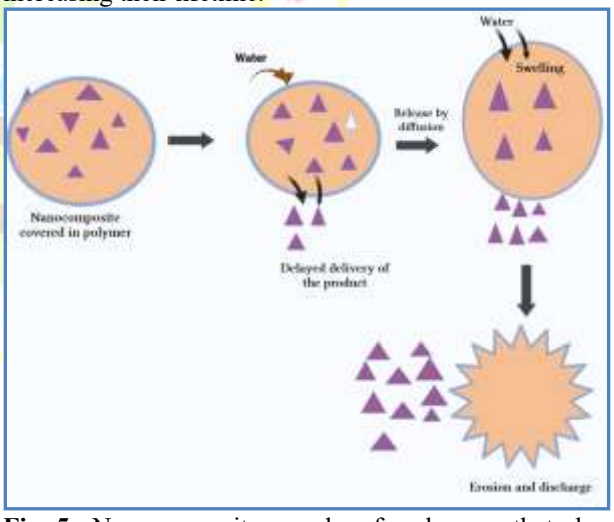

Fig 5. Nanocomposites made of polymers that, by absorbing water, encourage the gradual release of agricultural chemicals

When these ENCs (engineered nanocomposites) are dissolved in a solution, nutrients may be readily released from them in the form of soluble ions. In order to create effective nanoencapsulated techniques, it is possible to administer the nutrient components in a way that results in an encapsulated nanofertilizer that is specifically designed for controlled release. A number of factors, such as particle size, distribution, solubility, shape,

surface area, encapsulation mechanism, and release mechanism, should be carefully taken into account. Emulsification, coagulation, inclusion complexation, solvent displacement or nanoprecipitation, are some of the most frequently utilised nanoencapsulation processes. Along the use of fluorescently tagged nanocarriers for the transport and release of agrochemicals, Liu et al. (2015) have made it possible to easily trace chemicals through the food chain using an easy fluorescence detection system. They have created a special pesticide nanocarrier that utilises water-soluble cationic dendrimers. Its structure includes a core made of fluorescent perylenediimide (PDI), which is coupled to hydrophobic polyesters and periphery amino acids. (Sikdar *et al.,*2021).

Herbicide was combined with natural-synthetic PLA/PBAT polymers by Akhir and Mustapha (2022) in order to limit weed growth. A melt transesterification was used to create 2-methyl-4-chlorophenoxyacetic acid (MCPA) conjugated with poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) In order to create biodegradable mulch film with the addition of slow-release herbicides, the resulting bioactive oligomer herbicide was combined with PLA/PBAT (30/70).

Jayakumar et al. (2022) used cheese whey permeate as a substrate for *Bacillus megaterium* to synthesis and analyse the PHB-silver bionanocomposite (PHB-AgNc). TEM, SEM, FTIR, and NMR were used to characterise the extracted PHB-AgNc. High antimicrobial resistance is demonstrated by PHB-silver bionanocomposite against *E. coli* and *Pseudomonas* spp. A 96-hour batch fermentation experiment was conducted in a 14 L bioreactor. The greatest yields for both biomass and nanocomposite were 5.8 and 2.4 g/L, respectively.

Food packaging

As a result of substituting traditional plastic materials, PHB-based biocomposites have superior gas barrier qualities for packaging applications. This increase in demand is a result of rising environmental worries over the widespread use of synthetic, non-biodegradable polymeric packaging, namely polyethylene. The primary purpose of food packaging is to protect food products from microbial deterioration, toxic pollutants, oxygen, moisture, light, external force, etc. during storage and transit as well as to extend the shelf life of the food product. (Joseph *et al.,*2020) Environmentally friendly packaging made from naturally occurring polymers like Polylactide, PHB, and chitosan—which is particularly effective in food packaging—has been produced more often in recent years. Bioactive agents can be added directly to packing compounds to create antimicrobial packaging, coated on the surface of packaging to create antimicrobial packaging, or formed into films using antimicrobial polymers. (Jose *et al.,*2020) PHB, PLA, and starch and their derivatives have several properties that make them suitable with a variety of antimicrobial agents for packaging.

Vanillin, sophorolipid, and eugenol are a few examples of natural antimicrobials that were added to PHB-based biomaterials at various doses for active packaging materials. In a study, Zhong and his colleagues (2020) discovered that PHB films containing vanillin and eugenol, even at tiny amounts (80 g/g PHB), were effective against several bacterial species. Furthermore, adding these organic antimicrobials to PHB typically causes the films' thermal stability and mechanical qualities to decline.

Graphene nanoplatelets (GNPs) were used in the manufacturing of PHB-based film, according to Manikandan et al. (2020) as evidenced by the reduction of roughly 56.92% for WVP compared to the pristine film ($1.50 \times 10{-}^{10}$ $gm^{-1}h^{-1}$ Pa^{-1} WVP), they claimed that the addition of 0.7 weight percent GNP to PHB film showed the greatest barrier qualities. By forming a tortuous structure inside the matrix, impermeable GNP might be inserted, which would minimise permeability. These findings were directly connected to the longer shelf lives of milk and potato chips, which were 245 days and 26 days, respectively, as opposed to 60 days and 6 days for the control.

Alim et al. (2022) evaluated the modification of PHB film with thermoplastic starch (TPS), organically modified montmorillonite (OMMT), and eugenol (Eug). The thermal stability study revealed that the additives' presence had no appreciable impact on the degradation temperature of PHB film (Td: 299.20 °C). Additionally, when OMMT was added, the modulus increased by 12.82% compared to pure PHB, while it fell by 24.68% for the PHB/TPS film (1560 MPa).

Table 2. Biopolymer blended with nanoparticles shows antimicrobial activity

Nanoparticles	Biopolymer	Antimicrobial activity	Application
Ag	Chitosan	*E. coli, S. aureus, A. niger,* and *P. citrinum*	Active food packaging for litchi fruits
Ag	Nanostructured starch	*S. aureus, E. coli, and C.albicans*	Active food packaging
CuS	Agar	*E. coli* and *L. monocytogenes*	Active food packaging
ZnO	Ethyl cellulose	*E. coli* and *S. aureus*	Active food packaging
Silica	Chitosan	*E. coli, S. typhimurium, S.aureus, L.monocytogenes*	Active food packaging
TiO2	Wheat gluten and cellulose nanocrystals	*S. cerevisiae, E. coli, and S.aureus*	Active food packaging

Source: (Omerovic *et al.,*2021)

Recent investigations on composite films used to preserve bread for longer periods of time and using apricot kernel oil revealed total fungal growth inhibition (Guminnea *et al.,*2021). The antibacterial chemicals released by the active films developed by solvent casting were effective against the target microorganisms (Zhong *et al.,*2020). Fruit that has been coated with an edible substance aid in enhanced product stability and quality preservation (José *et al.,*2020). Applications of bio-composites should go beyond only packaging materials and include the development of biosensors that can quickly identify defective or tainted food, the presence of bacteria, and other things. (Joseph *et al.,*2020) Table 2.

Medical:

Due to their excellent biodegradability and biocompatibility, PHB-based biocomposites may have biological applications. In PHB's stereochemical regularity and a degree of crystallinity of 60–80%, which only use it in the biomedical field. (Raza *et al.,*2019) PEG-PHB-folic acid nanoparticle composite are created using the solvent evaporation method for oil/water emulsions. The medication paclitaxel was added to the produced nanoparticles. Results revealed that nanoparticles contained little amounts of drugs. It had a uniform distribution and little agglomeration. (Rezaei *et al.,* 2016)

Electrospinning and electrospraying were used to create PHB-based biocomposites scaffolds for PHB/HA (Koller *et al.,*2018). Naveen et al. (2020) successfully applied an electrospinning approach to produce PHB nanofibrous drug carriers using hexafluoroisopropanol (HFIP) as the solvent. These nanofibrous scaffolds displayed supported fast cell growth without negatively effecting cellular morphology; a cell viability of 87% was attained after 48 h.

By electrospinning thin films of P3HB-nHA, Chen et al. (2017) were able to observe that bone marrow mesenchymal stem cells had more favourable adhesion, proliferation, and osteogenic characteristics than P3HB-only cells did. Based on P3HB and HA, Degli Esposti et al. (2019) created bioactive and biodegradable porous scaffolds for bone tissue regeneration. In order to repair significant radial parietal bone lesions in rats, Ielo et al.(2022) examined the osteogenic potential of hybrid composite P3HB-Alg-HA scaffolds on mesenchymal stem cells (MSCs) Biocomposites including PHB and PHV sutures for biomedical applications and PHB composites containing HA for bone tissue engineering have both been produced using this material extensively. PHB/cellulose, PHB/chitosan, PHB/PEG, and PHB/HA composites all had improved thermal and mechanical properties.

CONCLUSION

The development of renewable feedstocks that are not sources of food or feed has been sparked by the present trends and difficulties in industrial biotechnology with regard to sustainability. Bioplastics have drawn a lot of interest in recent years from academic and industry researchers among the many green goods that are now on the market. PHB is the highest performing biopolymer currently on the market, and its widespread use would significantly ease the strain on the finite supplies of fossil fuels. However, the high cost of PHB production prevents the PHB production technique from being really commercial. For example, building up effective aerobic fermentation facilities and purchasing diverse feedstocks and organic solvents for polymer extraction both come at a significant capital cost. Due to this biopolymer's fundamental characteristics of biodegradability and biocompatibility, it is now possible to see it being widely used as a drug carrier in the biomedical area, as a nanoencapsulation of agrochemical in agriculture, as a biocomposite in nanotechnology, and in the food business. Biocomposites are made by mixing inorganic nanoparticles with biofilm-forming elements such polysaccharides, proteins, and nucleic acids. Agriculture, food packaging, pharmaceuticals, biosensors, and biofuels all make extensive use of biocomposites. In this overview, several recent developments in the design of agrochemical-controlled release systems are highlighted. It is obvious that using controlled release devices to apply agrochemicals can lower the total use of pesticides and commercial fertilisers. The excellent potential of biodegradable films made of nanomaterials for active packaging increases shelf life and preserves or enhances the quality of packaged goods.

Future Outlook:

The use of PHB and related composites as packaging materials, controlled-release delivery systems, and medication carriers has a lot of potential. PHB has a wide range of claimed commercial uses, from packaging to biological applications. PHB biocomposite may be created using a variety of techniques, but electrospinning has emerged as the most promising. There are several ways to PHB is more suited for usage as scaffolds after plasma treatment because it can encourage compatibilization between hydrophilic fibres and hydrophobic matrix through free radicals and surface cross-linking. As they provide for the best quality and safety of food, active antimicrobial packaging is a novel idea in food packaging that is attracting interest among researchers as well as among manufacturers and representatives of the packaging sector. Therefore, future research should concentrate on avoiding tying antimicrobial effects to the rate of microbial growth in packaged foods using both industrial and laboratory methods. This will aid in the early development of packaging that is resistant to microbes. Synergy, nanocomposites, and blending are examples of antimicrobial performance improvement tactics that will be essential tools to improve antimicrobial packaging and get around some operating restrictions. Despite the fact that bio-nanomaterials have many benefits, there is still much to be done to adapt these materials. Nanomaterials can't be commercialised because of

technical issues including incompatibility, uneven dispersion, and poor surface adhesion between them and substrates. To have a more sustainable method of obtaining ecologically acceptable biomaterials that are superior candidates for next-generation multi-modified biofilms, these problems still need to be solved.

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Research Article

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Correlation study of yield attributing traits in maize (*Zea mays* L.)

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ABSTRACT
Trial was led at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India during *rabi* season of the years 2019-20 and 2020-21 to study the association of yield attributing traits in maize under INM treatments. Number of cobs per plant sowing highly significant positive correlation with the all-other traits under evaluation. Number of cobs per plant and Number of seeds per cob in the year 2019-20 showing positive significant genotypic correlation with the grain yield per plant whereas phenotypic correlation is non-significant. Evaluation of the maize with the same treatments for the two subsequent years and getting same result, suggesting efficacy of the experimental selection and validating the results. This study will provide early yield prediction by considering effect of INM treatments on yield attributes.
Keywords: Correlation, Maize, INM and Selection.

INTRODUCTION

Maize (*Zea mays* L.) is dominating as cereal crops in the global agricultural economy, together as a food for human and as a feed for farm animals. Because of its extreme yield potential (22 t/ha) and unique photosynthesis mechanism owing to the C_4 mechanism, it is known as a "Queen of cereals". As a miracle crop; it has an advanced level of industrial use because of its differentiated by products, yield potential and broad genetic base. It is being widely grown in tropics, sub-tropics and temperate regions under irrigated to semi-arid conditions across the world. Renowned Nobel Laureate, father of the green revolution Dr. N. E. Borlaug has declared maize as the crop of the prospect.

Maize is cultivated worldwide with most of soil types, climate and management practices that gives 36% (782 MT) global production. The USA is the chief producer of maize and supporting nearly about 35% of the total global production (Farmers Portal, 2022). Currently, nearly 1147.7 million tonnes of maize is being produced together by over 170 countries from an area of 193.7 million hectares with average productivity of 5.75 t/ha (World Maize Scenario, 2022).

After rice and wheat, maize has appeared as the third most vital cereal crop covering an area of 9.60 million ha with the production of 27.15 mt, having average productivity of about 2.8 t/ha. Major states cultivating maize are RJ, MH, GJ, UP, KA, MP, AP and J&K. In Gujarat, maize is grown in the districts of Panchamahal, Sabarkantha, Banaskantha and part of Vadodara and Kheda. *Rabi* maize is having an area of 13,2300 hectares with a production of 33,3600 million tonnes and productivity of 2521 kg/ha in Gujarat (Anon., 2021).

An evaluation of the correlation among different characters gives an idea of association that could be efficiently exploited to articulate selection strategies of appropriate INM treatment for improving yield attributes.

MATERIALS AND METHODS

Trial was led at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India during *rabi* seasons of the years 2019-20 and 2020-21 to study the association of yield attributing traits in maize under INM treatments. The twelve integrated nutrient management treatments *viz.,* 100% RDF (T1), 100% RDF + NPK Consortium (Seed treatment) (T2), 100% RDF + NPK Consortium (Soil application) (T3), 75% RDF + 25% RDN through FYM (T4), 75% RDF + 25% RDN through Castor cake (T5), 75% RDF + 25% RDN through Vermicompost (T6), 75% RDF + 25% RDN through FYM + NPK Consortium (Seed treatment) (T7), 75% RDF + 25% RDN through Castor cake + NPK Consortium (Seed treatment) (T8), 75% RDF + 25% RDN through Vermicompost + NPK Consortium (Seed treatment) (T9), 75% RDF + 25% RDN through FYM + NPK Consortium (Soil application) (T10), 75% RDF + 25% RDN through Castor cake + NPK Consortium (Soil application) (T11) and 75% RDF + 25% RDN through

Vermicompost + NPK Consortium (Soil application) (T12) were applied in Randomized Block Design with three replications. Statistical analysis was performed using R software and variability package.

RESULTS AND DISCUSSION

Most of the soil parameters were positively correlated with grain yield (Kumar and Singh, 2021) as it regulates the healthy growth and potential yield of the plant. Correlation analysis revealed that phenotypic correlations were a little higher in amount than genotypic correlations indicating that expression was poor because of the effect of environment in both the years. All the yield attributing traits have positive significant correlation for grain yield. Indicating cumulative influence on the yield.

Number of cobs per plant in the 2019-20 showing positive significant genotypic correlation with the gain yield per plant whereas phenotypic correlation is non-significant (Table 1), indicating influence of environment on the interaction between yield and number of cobs, whereas in the year 2020-21 it's a highly significant correlation between number of cobs and yield per plant (Table 2). This variation in two years indicating influence of environment on expression of trait. Same pattern of relation was also observed between number of cob and number of seeds per cob in both years. Number of cobs per plant sowing highly significant positive correlation with the all-other traits under evaluation (Table 1 & 2). Similar result for Number of cobs per plant was also observed by Akshaya *et al.* (2022).

Cob length is important trait as it can directly correlate with the yield. In the study we observed positive significant correlation of cob length with the grain yield and all other attributing traits in both year 2019-20 and 2021-22 (Table 1 & 2). As the cob length increases number of seeds per cob will also increase and ultimately yield will increase as it is dependent trait. Similar result for Cob length was also observed by Jagadev *et al.* (2021) and Viveka *et al.* (2022).

Higher cob girth will accumulate a greater number of rows per cob that will ultimately increases number of seeds per cob and seed yield. Here in this study, we observed cob girth is showing positive highly significant correlation with the grain yield (Table 1 & 2). Cob girth is also showing positive significant correlation with number of cobs, cob length, number of seeds and seed index in both year 2019-20 and 2021-22. Similar result for cob girth was also observed by Jagadev *et al.* (2021), Krishna *et al.* (2021) and Viveka *et al.* (2022).

Number of seeds per cob is showing highly significant genotypic correlation with all the yield attributing traits under study whereas for phenotypic correlations it is showing non-significant correlation only for number of cobs per plant. Similar result for Number of seeds per cob was also observed by Jagadev *et al.* (2021), Krishna *et al.* (2021) and Viveka *et al.* (2022).

Seed index is the weight of 100 seeds which is also directly correlated with the yield. In our study we observe highly significant correlation with the all-attributing traits (Table 1 & 2). Similar result for Seed index was also observed by Jagadev *et al.* (2021), Krishna *et al.* (2021), Akshaya *et al.* (2022) and Viveka *et al.* (2022).

Table 1. Correlation of yields attributes in maize (Year 2019-20)

		Number of cobs/ plant	Cob length	Cob girth	Number of seeds per cob	Seed index	Grain Yield
NC	Rg	1 **	0.564 **	0.734 **	0.892 **	0.380 **	0.593 **
	Rp	1 **	0.524 **	0.470 **	0.280 NS	0.435 **	0.212 NS
CL	Rg		1 **	0.358 **	0.101 **	0.053 **	0.194 **
	Rp		1 **	0.674 **	0.856 **	0.805 **	0.646 **
CG	Rg			1 **	0.401 **	0.304 **	0.593 **
	Rp			1 **	0.621 **	0.604 **	0.402 *
NS	Rg				1 **	0.165 **	0.278 **
	Rp				1 **	0.821 **	0.627 **
SI	Rg					1 **	0.133 **
	Rp					1 **	0.756 **
GY	Rg						1 **
	Rp						1 **

Table 2. Correlation of yields attributes in maize (Year 2021-22)

		Number of cobs/plant	Cob length	Cob girth	Number of seeds per cob	Seed index	Grain Yield
NC	Rg	1 **	0.563 **	0.735 **	0.433 **	0.426 **	0.083 **
	Rp	1 **	0.451 **	0.333 *	0.435 **	0.350 *	0.339 *
CL	Rg		1 **	0.218 **	0.126 **	0.043 **	0.077 **
	Rp		1 **	0.778 **	0.770 **	0.838 **	0.565 **
CG	Rg			1 **	0.044 **	0.071 **	0.310 **
	Rp			1 **	0.780 **	0.842 **	0.523 **
NS	Rg				1 **	0.036 **	0.047 **
	Rp				1 **	0.894 **	0.659 **
SI	Rg					1 **	0.154 **
	Rp					1 **	0.709 **
GY	Rg						1 **
	Rp						1 **

CONCLUSION

Results of this experiment showing the considerable positive association of all the yield attributes of the maize towards the yield. Evaluation of the maize with the same treatments for the two succeeding years and receiving same result suggesting efficacy of the experiment and validating the result. As per the nutrient supplements in the soil cob number, girth, and seed index will change and affect final yield. This study will provide early yield forecast by considering effect of INM treatments on yield attributes and thereby selection of best INM for yield and its attributes.

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Research Article

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Production performance of Holstein crossbred cows under the existing farming system in a certain area of Bangladesh

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ABSTRACT
This study aimed to assess the effect of existing feeding system on milk yield and nutritional status and profitability of 75.0% and 87.5% Holstein crossbreed cows under existing farming system in an area of Bangladesh. In a milk pocket area (Keraniganj, Dhaka), three dairy farms termed F1, F2 and F3 were randomly selected having 34, 55 and 19 lactating cows, which 75% and 87.5% Holstein blood were 48 and 60, respectively. Using pretest questionnaire information like body weight, daily milk production, parity number, days in milking, blood percentage and feeding system of each animal were noted throughout a year. All data of three farms were subjected to analyze in one-way ANOVA in terms of 75% and 87.5% Holstein cows, separately. The body weight (kg) of 75% Holstein were F1 (296), F2 (497) and F3 (496) cows ($p<0.05$), while daily milk yield (kg) did not differ markedly among F1 (9.1), F2 (10.5) and F3 (13.9) ($p>0.05$), respectively. 75% Holstein of F1 offered almost, metabolizable energy (ME) and digestible crude protein (DCP), while cows of F2 and F3 fed daily insufficient DCP (-0.14kg) and over DCP (+0.47kg), respectively thus resulting in 37.2% less milk yield in F3 compared to F2 ($p<0.05$). Besides, 87.5% cows of F1, F2 and F3 had 365, 528 and 566kg body weight ($p<0.05$) and daily produced 10.5, 10.8 and 19.4kg milk ($p>0.05$), respectively. However, 87.5% cows of F1 daily offered almost balance ME and DCP, while the cows of F2 fed lower DCP (-0.2kg). Then, cows of F3 daily fed excessive DCP (+0.14kg) thus resulting in produced 8.6kg higher milk than cows of F2. Net return except depreciation cost from 75% cows of F1, F2 and F3 were 118, 170 and 145BDT, while 87.5% cows of F1, F2 and F3 were 189, 196, and 413BDT ($p>0.05$), respectively. It may be concluded that under existing feeding system and farming practices, cows from the F1, F2, and F3 of 75% and 87.5% Holstein blood daily produced 9.8, 10.7 and 16.7kg of milk per day with 330, 512, and 531kg body weight on average, generating 154, 183, and 279BDT in profit, respectively. Feeding lower nutrient to dairy cows resulted better milk yield and return at the sacrifice of cow fitness, while excessive feeding lead to higher milk yield but lower return, whereas optimum nutrition resulted in better milk yield and return.
Keywords: Crossbred, milk yield, nutritional status, body weight and profit.

INTRODUCTION

Crops, fisheries and livestock are the key agricultural sector of Bangladesh in which the dairy industry has emerged as a promising sub-sector. Earlier the rural people merely raised indigenous dairy cattle to meet their family's milk demands. However, the indigenous cows are low producer due to possess poor genetic makeup and provide low-quality crop residue mostly rice straw (Van Soest, 2006). Moreover, indigenous cattle and rice straw were the main drawback to get more milk for the nation (Hossain et al., 2005). To solve these problems, crossbreeding policy, well-balanced feeding and management have been recognized as a realistic approach to enhance the poor productivity of indigenous cattle, thus resulting in enhanced farm profitability (Xue et al., 2011; Buckley et al., 2014). Consequently, the Bangladeshi government, private and autonomous organizations took the necessary measures to upgrade the genetic potential of indigenous dairy cattle through artificial insemination (AI) of two or three generations of crossbred dairy cows (Uddin et al., 2014). Due to the widespread use of AI in both urban, peri-urban and rural areas, cow's genetic merit is changing towards Holstein blood which has resulted in a sharp rise in milk production in the nation (DLS, 2022). Another barrier for increasing milk production is lack of supply of accessible green fodder, since earlier the farmers did not allocate land for fodder production due to higher demand of human food (Islam et al., 2017). Recently fodder production has become a commercial trade in dairy pocket area (Roy et al., 2012).

Keraniganj is a dairy pocket area nearest to Dhaka city having roughly 2560 cattle farms, 70560 cows, 21.65 metric ton milk production per day (DLS, 2022). There is a tremendous demand for milk due to peak availability of consumers and easy access to the milk market.

Consequently, a large number of specialist dairy farms have been established, using high producing crossbred cows such Holstein Friesian, Jersey, and Sahiwal crossbred, who are fed roughage and concentrate mixture for maintenance and production. However, giving cows an excessive or inadequate amount of nutrients, particularly energy and protein, causes imbalanced performance in dairy cows and decreased farm profitability (Erickson and Kalscheur, 2020). So, feeding system is the foremost factor in farming system as it drives the productivity and covers more than 65% of cost related to farming. But, still now the feeding system and constraints for profitability have not studied among the existing specialized farmers where dairying has gaining popularity. Considering Keranigonj as promising peri-urban dairy the study has conducted among the farmers targeted to characterize the feeding system and determine the productivity, nutritional performance and profitability of farms.

MATERIALS AND METHODS

Study area and farm's selection

The current survey was executed on crossbred dairy cows rearing in different specialized dairy farms at Keraniganj Upazila (Location 23°70′06.5″ N, 90°39′73.0″E), in Dhaka, Bangladesh. Arbitrarily three specialized crossbred dairy farms were chosen and presented as F1, F2 and F3, respectively. In F1, F2, and F3, there were 101, 155, and 44 cattle, respectively, with 42, 70, and 22 lactating cows.

Data collection

The data linked to crossbred lactating cows of F1, F2, and F3 were collected using a well-structured pretest questionnaire from June 2020 to July 2021 through face-to-face interview and herd record. At first from herd record, the genetic excellence of the crossbred lactating cows was documented properly from three farms. In F1, F2 and F3, there were 13, 26 and 9 number of 75% Holstein blood lactating cows and 21, 29 and 10 number of 87.5% Holstein blood lactating cows, respectively. Data on body weight of each lactating cow of three farms were calculated in accordance with Schaeffer's formula (Wangchuk et al., 2018). Data on milk yield, body weight, parity number, days in milking, pregnancy status of individual lactating cows of each farm were accurately documented for the calculation of nutrients requirement of specific lactating cows. The amount of roughage and concentrate supplied and leftover for the specific lactating cows were documented each day and the intake was measured by subtracting the feed supplied from leftover. In each farm, specific lactating cow was offered in a common range of roughage and concentrate feed on the basis of milk yield, pregnancy status and body weight in two feeding monsoons namely January to July and August to December in a year (Table 1).

The proximate components of different feed ingredients fed to animals were measured in terms of few ingredients (local concentrate mix and local grass) by AOAC, (2005); and rest ingredients value were used from referred value. Then the nutrients concentration of roughage and concentrate feed were calculated from the analyzed and book value (Table 2).

Nutrient requirements supply and balance

Dry matter (DM) requirements for specific animal were calculated on the basis of Thumb rule using body weight of animal (DM- 3.0% of body weight). In each farm, metabolizable energy (ME) for maintenance and production were calculated for specific animals, while digestible crude protein (DCP) for each animal were designed by adopting the equation of ARC, (1980).

The nutrients supply for each animal was calculated from the roughage and concentrate intake and using their nutrient concentration. Finally, the nutrients balance for each animal was calculated by subtracting the nutrient supply from nutrient leftover.

Economic and statistical analysis

In F1, F2 and F3 feed supplied through roughage cost daily almost 34.0, 30.0 and 33.0BDT for each cow, respectively. Concentrate price almost 36.0BDT/kg and other cost also included for each dairy cows. Milk sold price 70 BDT/kg from farm gate.

All data were subjected to one-way ANOVA, and the significance of differences among mean was determined using the Duncan multiple range test in IBM SPSS 2021 (Version 20.0; IBM Corp., Armonk, New York, USA) and the differences at $p<0.05$ were considered statistically significant.

Table 1. Feeding strategy practiced in different specialized farms

Feed description	Time frame	F1	F2	F 3
Roughage	January-July	Jumbo grass (15-20 kg) and local grass (1-2 kg)	Jumbo or maize grass (13-18 kg) and molasses treated rice straw (1.5-2.5 kg)	Water hyacinth (25-30 kg)
	August-December	Water hyacinth (20-25kg) and local grass (1-2 kg)	Local grass and water hyacinth (10-12 kg)	
Concentrate	January-July	Mixed bran (4-5 kg) and boiled concentrate mixture (5.5-6.9 kg)	Mixed bran (5.5-8.5 kg) and compound feed (1.0- 3.0 kg)	Mixed bran (11.5-16.5 kg)
	August-December		Mixed bran (6.5-10.5 kg) and compound feed (1.9-3.0 kg)	
Total roughage	January-July	16-22 kg	14.5-20.5 kg	25-30 kg
	August-December	21-27 kg	10-12 kg	
Total concentrate	Year round	9.5- 11.9 kg	14.9- 25 kg	11.5-16.5 kg

F1=Farm-1, F2=Farm-2, F3=Farm-3, kg=kilogram

Table 2. Calculated nutrient composition of roughage and concentrate from supplied feedstuff

Farm	DM%		CP%		ME (MJ/Kg DM)	
	Roughage	Concentrate	Roughage	Concentrate	Roughage	Concentrate
January- July						
F1	17.00	87.5	9.78	13.21	7.94	12.43
F2	21.89	89.6	8.56	13.34	7.59	12.15
F3	11.50	89.2	12.34	13.54	7.32	12.19
August- December						
F1	12.45	87.5	11.25	13.21	7.32	12.43
F2	87.12	89.6	3.87	13.34	7.18	12.15
F3	11.50	89.2	12.34	13.54	7.32	12.19

F1=Farm-1, F2=Farm-2, F3=Farm-3, DM=Dry matter, CP=Crude protein, ME=Metabolizable energy, MJ/kg=Mega-joule per kilogram

RESULTS AND DISCUSSION

Performance of 75% Holstein crossbred cows (Table 3)

Cows bearing 75% Holstein blood had 296, 497 and 496kg BW ($p<0.05$) and produced daily 9.13, 10.52 and 13.92kg milk ($p>0.05$) in F1, F and F3, respectively. Cows of F1 showed 68% lower BW but daily produced 37-46% higher milk than F2 and F3.

Nutritional status of 75% Holstein crossbred cows (Table 4)

75% Holstein cow daily required 8.8, 14.9, and 14.8kg of DM, but were fed 10.2, 11.3, and 18.6kg of DM in F1, F2, and F3, respectively which varied differently ($p<0.05$). In F1, F2 and F3 the cows offered correspondingly, 62, 66, and 75% DM through concentrate and 38, 34, and 25% DM through roughage. Cows of F1 (+3.7kg) and F3 (+9.0kg) received excess DM, but F2 got less DM (-0.7kg) than was required. Total metabolizable energy (TME) and ME for maintenance varied significantly among the farms, whereas ME for production did not. Cows were given 2.64, 3.12, and 4.96 times ME through concentrate in the F1, F2, and F3 compared to roughage, respectively. Cows of F1 (28MJ), F2 (16MJ) and F3 (83MJ) received extra ME, respectively. Digestible crude protein requirement, supply and balance differed substantially among the farms ($p<0.05$). Cows consumed 27 and 73% of DCP through roughage and concentrate in F1, 17 and 83% in F2, and 19 and 81% in F3 ($p<0.05$).

Performance of 87.5% Holstein crossbred cows (Table 5)

Cows with 87.5% Holstein blood had BWs of 365, 528, and 566 kg ($p=0.051$) and daily milk yield of 10.5, 10.8, and 19.4 kg ($p>0.05$) in the F1, F2 and F3, respectively. About 85 and 82% higher milk was produced by cows of F3 than by F3 and F2, respectively.

Nutritional status of 87.5% Holstein crossbred cows (Table 6)

For the 87.5% Holstein cows in the F1, F2 and F3, the daily DM requirement was 10.9, 15.8, and 16.9 kg, respectively ($p<0.05$), whereas the cows consumed daily feed of 10.7, 11.2 and 18.4 kg of DM from roughage and concentrate. Moreover, the dry matter balance in F1 and F2 were negative, but F3 was surplus. ME requirement for maintenance, supplied through roughage and concentrate, and positive balance differed substantially among the farms ($p<0.05$). The cows fed ME through roughage and concentrate feed were 27 and 73% in F1, 24 and 76% in F2, and 12 and 88% in F3, respectively. Daily DCP requirements per cow did not differ among farms ($p<0.05$), while daily DCP supplied through concentrate and roughage varied across farms ($p<0.05$). However, the cow from F3 received almost daily two times DCP compared to F1 and F2 cows. ME supplied through roughage and concentrate were at a rate of 26 and 74% in F1, 17 and 83% in F2 and 14 and 86% in F3, respectively. Daily DCP balance was negative in F1 and F2, while it was positive in F3; this difference was substantial ($p<0.05$).

Cost analysis of three farms of 75% and 87.5% Holstein crossbred lactating cows (Table 7)

Daily feed cost, other cost and total cost for dairy production significantly varied from farm to farm ($p<0.05$), whereas daily sale milk price and profit did not show any significant variation among the farms ($p<0.05$) in terms of cows bearing 75% and 87.5% Holstein blood. In both Holstein blood, daily feed cost, other cost and total cost for dairy operation was obtained higher in F3 and then F2 and F1, no significant variation was obtained between F1 and F2. Profit for cows with both Holstein blood was inconsequent among the farms ($p<0.05$) but better profit was obtained in F2 (170 BDT) and F3 (413 BDT) in 75% and 87.5% Holstein blood, respectively.

Body weight and milk production

The body weight of lactating cows varied significantly among F1, F2, and F3, but the milk yield was consistent. Previous research suggested that cows with 92% and 52% Holstein blood showed 602 and 603 kg body weight, respectively, which is greater and contradicts the results of the current study (Buckley et al., 2014). This lower body weight of lactating cows among the three farms of 75% and 87.5% Holstein blood due to fed imbalanced and different level of nutrition caused lower growth rate of calves and heifers (Roche et al., 2009; Erickson, and Kalscheur, 2020). Additionally, the lower and diverse body weights of the lactating cows in the current study might be attributed to the differing weights of crossbred cows that were bred using semen from Holstein or Sahiwal at various farms. The current study's milk yield was slightly influenced by the cows' poor nutrition and lower body weight. The average milk production of local cows were daily 2.26kg (Miazi et al., 2007), but we found higher milk yield in three farms of 75% and 87.5% Holstein blood, which is aligned to the previous finding (Sae-tiao et al., 2019). However, Miazi et al. (2007), stated that milk yield of crossbred Holstein and Sahiwal was about 6.0kg under village condition of Bangladesh which is lower compared to current study. This higher milk yield of both Holstein blood might be attributed due to genetic up-gradation, nutritional balance, and proper management of cows.

Table 3. Performance of 75% Holstein crossbred cow of three farms

Variables	F1	F2	F3	SEM	p-value
Body weight (kg)	295.6b±61.5	496.5a±65.4	496.2a±59.7	37.99	0.011
Milk yield (kg)	9.13±1.8	10.52±2.9	13.92±2.8	1.03	0.144
% milk yield relative to Farm 1	100	115.2	152.43		
% milk yield relative to BW	3.09	2.12	2.80		

F1=Farm-1, F2=Farm-2, F3=Farm-3, Number of cattle in F1=13, F2=26, F3=9, kg=Kilogram, MY=Milk yield, a-c Means in the same row with no common superscript differ significantly ($p<0.05$).

Table 4. Comparison of nutritional status of three farms of 75% Holstein crossbred cows

Variables	F1	F2	F3	SEM	P-value
Requirements					
Dry matter (kg/cow/day)	8.8^{b}±1.8	14.9^{a}±1.9	14.8^{a}±1.7	1.14	0.011
ME (MJ/cow/day)	74.0^{b}±12.3	102.9^{ab}±18.3	121.2^{a}±19.4	8.45	0.039
Maintenance (MJ/cow/day)	35.2^{b}±5.6	53.4^{a}±5.9	53.4^{a}±5.4	3.46	0.011
Production (MJ/cow/day)	38.8^{b}±9.1	49.4^{ab}±16.3	67.8^{a}±14.9	5.82	0.105
DCP (kg/cow/day)	0.72^{b}±0.13	1.02^{ab}±0.19	1.21^{a}±0.20	0.09	0.038
Intake					
Dry matter (kg/cow/day)	10.2^{b}±0.5	11.3^{b}±0.7	18.6^{a}±0.4	1.34	<0.001
Roughage (kg/cow/day)	3.8^{b}±0.2	3.8^{b}±0.2	4.6^{a}±0.4	0.16	0.036
Concentrate (kg/cow/day)	6.3^{c}±0.5	7.4^{b}±0.6	13.9^{a}±0.0	1.21	<0.001
ME (MJ/cow/day)	107.4^{b}±25.6	119.0^{b}±8.0	203.9^{a}±2.9	16.35	<0.001
Roughage (MJ/cow/day)	29.8±1.8	28.9±1.6	34.2±3.2	1.06	0.073
Concentrate (MJ/cow/day)	78.6^{b}±6.6	90.1^{b}±7.3	169.7^{a}±0.8	14.42	<0.001
DCP (kg /cow/day)	0.83^{b}±0.05	0.88^{b}±0.06	1.68^{a}±0.02	0.14	<0.001
Roughage (kg /cow/day)	0.22^{b}±0.01	0.15^{c}±0.01	0.31^{a}±0.02	0.02	<0.001
Concentrate (kg /cow/day)	0.61^{c}±0.05	0.72^{b}±0.05	1.36^{a}±0.00	0.12	<0.001
Balance					
DM (kg/cow/day)	3.7^{b}±0.1	-0.7^{c}±0.0	9.0^{a}±0	1.41	<0.001
ME (MJ/cow/day)	28.4^{b}±2.1	16.0^{c}±0.5	82.6^{a}±0.3	10.23	<0.001
DCP (kg/cow/day)	0.11^{b}±0.0	-0.14^{c}±0.0	0.47^{a}±0.0	0.08	<0.001

F1=Farm-1, F2=Farm-2, F3=Farm-3, Number of cattle in F1=13, F2=26, F3=9, DM =Dry matter, Kg=Kilogram, MJ=Mega-joule, DCP=Digestible crude protein, $^{a-c}$ Means in the same row with no common superscript differ significantly ($p< 0.05$)

Table 5. Performance of 87.5% Holstein crossbred cows of three farms

Variables	F1	F2	F3	SEM	P-value
Body weight (BW)	365.4^{c}±72.7	528.4^{ab}±60.8	565.9^{a}±105.4	38.79	0.051
Milk yield	10.5±3.0	10.8±4.1	19.4±6.4	2.00	0.103
% milk yield relative to Farm 1	100.0	103.0	185.0	-	-
% milk yield relative to BW	2.88	2.04	3.43	-	-

F1=Farm-1, F2=Farm-2, F3=Farm-3, Number of cattle in F1=21, F2=29, F3=10, kg=Kilogram, $^{a-c}$ Means in the same row with no common superscript differ significantly ($p<0.05$).

Table 6. Comparison of nutritional status 87.5% Holstein crossbred cows of three farms

Variables	F1	F2	F3	SEM	p-value
Requirements					
Dry matter (kg/cow/day)	10.9^{c}±2.1	15.8^{ab}±1.8	16.9^{a}±3.1	1.16	0.050
ME (MJ/cow/day)	89.6±20.1	108.1±24.5	154.79±39.3	12.85	0.080
Maintenance (MJ/cow/day)	41.5^{c}±6.6	56.3^{ab}±5.5	59.8^{a}±9.6	3.53	0.049
Production (MJ/cow/day)	48.0±16.6	51.7±21.2	94.9±32.4	10.30	0.101
DCP (kg/cow/day)	0.88±0.21	1.08±0.25	1.56±0.41	0.13	0.079
Intake					
Dry matter (kg/cow/day)	10.7^{b}±0.8	11.2^{b}±0.7	18.4^{a}±1.5	0.88	<0.001
Roughage (kg/cow/day)	4.0±0.3	3.8±0.2	3.4±0.2	0.11	0.097
Concentrate (kg/cow/day)	6.7^{b}±0.7	7.4^{b}±0.6	14.9^{a}±1.3	1.35	<0.001
ME (MJ/cow/day)	114.6^{b}±9.9	118.8^{b}±8.8	207.4^{a}±17.8	15.57	<0.001
Roughage (MJ/cow/day)	31.0^{a}±2.6	28.9^{ab}±1.5	25.44^{b}±1.6	1.00	0.038
Concentrate (MJ/cow/day)	83.6^{b}±9.3	89.9^{b}±8.3	181.9^{a}±16.6	16.27	<0.001
DCP (kg /cow/day)	0.88^{b}±0.07	0.88^{b}±0.07	1.71^{a}±0.14	0.14	<0.001
Roughage (kg /cow/day)	0.23^{a}±0.02	0.15^{b}±0.00	0.24^{a}±0.01	0.01	0.001
Concentrate (kg /cow/day)	0.64^{b}±0.07	0.72^{b}±0.06	1.46^{a}±0.13	0.13	<0.001
Balance					
DM (kg/cow/day)	0.2^{b}±0.0	-4.5^{c}±0.0	1.4^{a}±0.2	0.90	<0.001
ME (MJ/cow/day)	25.0^{b}±0.6	10.7^{c}±0.6	52.6^{a}±2.3	6.16	<0.001
DCP (kg/cow/day)	-0.005^{b}±0.008	-0.20^{c}±.007	0.14^{a}±0.02	0.05	0.001

F1=Farm-1, F2=Farm-2, F3=Farm-3, Number of cattle in F1=21, F2=29, F3=10, DM=Dry matter, Kg=Kilogram, MJ=Mega-joule, DCP=Digestible crude protein, $^{a\text{-}c}$ Means in the same row with no common superscript differ significantly ($p<0.05$).

Table 7. Comparison of economic analysis of three farms of 75% and 87.5% Holstein crossbred cows

Variables (Cost in BDT)	F1	F2	F3	SEM	p-value
75% Holstein					
Total feed cost	359.4b±27.6	390.3b±28.5	657.0a±17.3	47.78	<0.001
Other cost	161.7b±12.4	175.6b±12.8	209.0a±7.7	7.72	0.006
Total cost (I)	521.1b±40.0	566.0b±41.4	866.0a±10.5	54.99	<0.001
Milk sale price (II)	639.1±128.8	736.4±205.1	1011.0±147.2	73.02	0.073
Profit (II-I)	117.9±88.7	170.3±163.6	145.0±136.7	39.23	0.893
87.5% Holstein					
Total feed cost	378.9b±38.5	389.6b±31.1	654.1a±56.5	46.70	<0.001
Other cost	170.5b±17.3	175.3b±14.0	294.3a±25.4	21.02	<0.001
Total cost (I)	549.4b±55.9	565.0b±45.2	948.4a±82.0	67.72	<0.001
Milk sale price (II)	738.5±214.0	760.9±287.0	1361.5±449.0	139.96	0.103
Profit (II-I)	189.0±158.2	195.8±242.4	413.0±367.3	86.20	0.547

F1=Farm-1, F2=Farm-2, F3=Farm-3, Number of 75.0% Holstein blood cows in F1=13, F2=26, F3=9, and 87.5% Holstein blood, F1=21, F2=29, F3=10, Other cost =Feed additive, medication, vaccination, labor, miscellaneous, a-c Means in the same row with no common superscript differ significantly ($p<0.05$). Considering 69% feed cost and 31% other cost.

Nutritional status of dairy cows

Three farms had different requirements and supplies for DM, total ME, ME for maintenance and DCP in lactating cows with 75% and 87.5% Holstein blood. This noteworthy outcome was mostly brought about by differences in dairy cow's body weight and milk yield status among the three farms with both Holstein blood. Since earlier research demonstrated that lactating cows' requirements for DM, ME for production and maintenance, and DCP supply are mostly related to body weight and milk yield (Kearl et al., 1982; Erickson and Kalscheur, 2020). Greater amounts of DM, ME for production and maintenance, and DCP were required for animals with higher body weight and milk yield, and vice versa. The milk production of three farms was varied but not significant in the current investigation, which led to negligible ME requirements for production among three farms. Furthermore, it was found that 75% and 87.5% lactating cows fed surplus ME of three farms which was essential for pregnancy maintenance.

Economic analysis

Better profit was obtained in F2, F3 and F1 of 75% Holstein blood, while higher profit was found in F3, F2 and F1 of 87.5% Holstein blood, respectively. This variation may be due to following reasons: (i) poor feeding knowledge to dairy cows, (ii) higher milk production, and (iii) use of higher concentrate feed in dairy operation among the three farms. Lactating cows of F1 of both Holstein blood showed lower profits but did not lose body weight since they were well-fed and did not lack in ME and DCP. In the farm F2, both Holstein-blood percent of cows displayed better profit than others. Cows of F2 lost body weight by breaking down their muscles to meet their nutritional needs since they consumed less ME and DCP through feed (Roche et al., 2009). In F3, cows of both Holstein blood with higher body weight produced highest milk but failed to afford better return due to overfeeding of ME and DCP which resulted in higher nutrients loss through feces and caused environmental pollution (VandeHaar and St-Pierre, 2006).

CONCLUSION

It may be concluded that under the existing farming and feeding practices, cows with 75% and 87.5% Holstein blood from the F1, F2, and F3 had an average body weight of 330, 512, and 531kg, and daily milk production of 9.8, 10.7, and 16.7kg, which produced returns of 154, 183, and 279BDT, respectively. Therefore, it is logical to assume that body weight and milk production positively correlated. Better cow performance and return are driven by optimal nutrition; less feeding produced better return but at the sacrifice of cow health, whereas overfeeding produced lower returns.

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Research Article

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Air pollution level declines the bird species diversity in an urban area: a case study of Bilaspur, Chhattisgarh during the summer season

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ABSTRACT
With rapid growth and changes in daily life, air pollution is also increasing at a high rate. Air pollution threats are not only restricted to urban areas but harm rural areas also. Apart from being harmful to human beings; air pollution possesses a negative impact on bird species also. This study was carried out to find out the adverse impact of air pollution on the diversity of the avian community. The study was executed at five different locations in Bilaspur city during the summer season (2022). Vehicular emissions, burning of fossil fuels, constructions etc. are the major source of pollution in the city. The point count and checklist method was adopted for the observation of bird species. The air quality and pollution monitoring had been carried out through the 'Smiledrive Air Quality Monitor Pollution Meter' which detects the concentration and level of PM 2.5, PM 10, TVOC and HCHO in the air. The diversity of bird species was calculated through total species richness and the Shannon-Wiener diversity index. It was observed that the site having minimum pollution levels have a large bird population with maximum diversity and the sites having high pollution levels have the least diversity of birds. It is the reason that many bird species avoid areas with high pollution concentrations. The study also revealed the remarkably high population of birds of the 'Sturnidae' and 'Columbidae families in polluted sites which validates that the birds of these families have adapted themselves well in the sites with high pollution levels.
Keywords: Air pollution, birds, diversity, urban area.

INTRODUCTION

In today's era where the world is changing very fast, air pollution is emerging as a serious problem. This phenomenon is not only restricted to urban areas but also becoming common in rural areas. Atmospheric pollutants that arise from human activities exert a widespread effect on all living organisms. In this regard, human health has always been the primary concern of research (Gupta and Bakre *et al*., 2013). Various anthropogenic activities like vehicular emission, burning of fossil fuels, construction, industrialization, combustion etc. are the major source of pollution in the city. Yadav *et al*., (2012), explain that the air pollution problem is associated with vehicular emissions.

Air pollution is a major threat not only to human beings but to bird species also. Avian species are more likely to be susceptible to the high concentration of reactive gases and aerosols in the air than mammalian species, and so may serve as useful indicators of air quality (Brown *et al*., 1997). With rapid urbanization and industrialization, the green cover is declining at a very fast rate and the air quality of cities is getting worse day by day. Very few studies have been carried out to study the consequences of urbanization on birds (Sengupta *et al*., 2014). Birds in urban area have to face the challenges like availability of food materials, vegetation cover etc. Avian community is vulnerable to changes in the high concentration of pollutant matter in the air. Birds could also serve as sentinel species for air quality, as they are found globally, in both urban and rural areas, and make use of many different habitat types (Brown *et al*., 1997, Baesse *et al*., 2015).

This study was carried out to provide the response of the avian community towards air pollution and to find out the negative impact of air pollution on bird diversity.

MATERIALS AND METHODS

Study Site

This study was conducted in Bilaspur city which lies in the Chhattisgarh state of India. It is one of the major cities of the state. Bilaspur is divided by the winding Arpa River. The city is located at 22.0797^0 N Latitude 82.1409^0 E Longitude and the city is spread over an area of 205 km^2 with a mean sea level of 270 m. The summers are relatively hot and dry with maximum temperature reaching up to 49^0 C with average temperature being 33^0

C in summer and 15^0 C in winter. Bilaspur city has a sub-tropical, semi-arid and continental climate. The average rainfall varies between 580 mm to 680 mm.

The study was conducted in 5 different sites in Bilaspur city.

Site I [*Near Indira Setu Bridge*]: This area contains less vegetation cover and has heavy vehicular traffic throughout the day. (Fig.1)

Site II [*Nehru Chowk*]: This is the main square of the city and it is bustling here all day. This site contains adequate tree cover and vegetation. (Fig.2)

Site III [*Rajendra Nagar Chowk*]: This site contains a municipal park, open space and less traffic disturbance with a lot of greenery and tree cover. (Fig.3)

Site IV [*Collectorate Office*]: The area has local administrative offices with a lack of greenery and a high frequency of transportation and masses coming here. (Fig.4)

Site V [*Main Post Office*]: This area has moderate vehicular traffic along with sparce trees and vegetation. (Fig.5)

Fig.1: Location I: Near Indira Setu Bridge

Fig.2: Location II: Nehru Chowk

Fig.3: Location III: Rajendra Nagar Chowk

Fig.4: Location IV: Collectorate Office

Fig.5: Location V: Main Post Office

Bird Count

For the counting and sampling of birds, the point count method was applied (Bibby *et al*., 2000; Vielliard *et al*., 2010) in which fixed sampling points were established at a minimum distance of 200 m. apart, to minimize the chances of recording the same individuals at more than one point and also allowed the detection of species. Data were collected in the summer season from 5 different locations in Bilaspur city from April 2022 to June 2022. Birds have been recorded in two phases; the first phase is in the morning from 06:00 hrs to 09:00 hrs and the second phase is from 4:00 p.m. hrs to 18:00 hrs (Vishwakarma *et al*., 2021). The number of points varied to provide equal sampling coverage. In total 25 sampling points were used and each point was sampled for 15 minutes and the bird species seen or heard were recorded.

For observations, Binocular- Nikon Aculon 10 x 50 and Camera- Canon 700D with 100-400 Tamron Lens and Nikon P_{900} 83x zoom lens were used; and for bird identification Grimmett *et al*., 2013 was referred.

Air Pollutants

The monitoring of air quality and pollution had been done through 'Smiledrive Air Quality Monitor Pollution Meter". The instrument detects the concentration and levels of PM 2.5, PM 10, TVOC and HCHO in the air.

This monitoring device is placed at the selected 5 locations in the city. The device is first calibrated and then kept stationary for 20 minutes for recording the observations. The same course of action is performed at each selected site to record the concentration of pollutants. A total of 25 readings were taken and these observations were taken on the same day when the bird census was being done.

Data Analysis

Out of the 25 total observations recorded at the 5 selected sites (5 observations at each site); the recorded and the collected data is then analysed for the outcome.

The species richness was computed and species evenness and Shannon-Wiener diversity index were calculated using the total number of contacts of an individual species in each point count (Krebs 1998). The recorded air pollutant data was evaluated and the mean of each pollutant parameter (viz. TVOC, HCHO, PM 2.5 and PM 10) was calculated through total observed reading for each selected site. (Table 1).

Table 1. Mean of recorded air pollutants at each site

Site	Pollutants			
	TVOC (mg/m^3)	HCHO (mg/m^3)	PM 2.5 ($\mu g/m^3$)	PM 10 ($\mu g/m^3$)
I	0.528	0.064	66	79
II	0.182	0.028	36	40
III	0.111	0.025	32	36
IV	1.243	0.074	88	101
V	0.338	0.058	63	66

After the computation of pollutant data, species richness and Shannon-Wiener diversity index, the correlation coefficient was calculated to assess the relationship between the pollutant (viz. HCHO and PM 2.5) and the diversity of birds. The relation between two factors or entities can be established by correlation coefficient and thus, air pollution and biodiversity are interdependent (Tanveer A *et. al*., 2002).

RESULTS AND DISCUSSION

Air Pollutants

Through the statistical, tabular and graphical analysis of the recorded pollutant data, the following interpretation can be made:

The mean TVOC value (in mg/m^3) ranges from 0.111 to 1.243 (Fig.6) and the mean HCHO value (in mg/m^3) ranges from 0.025 to 0.074 (Fig.7) among all the 5 selected sites.

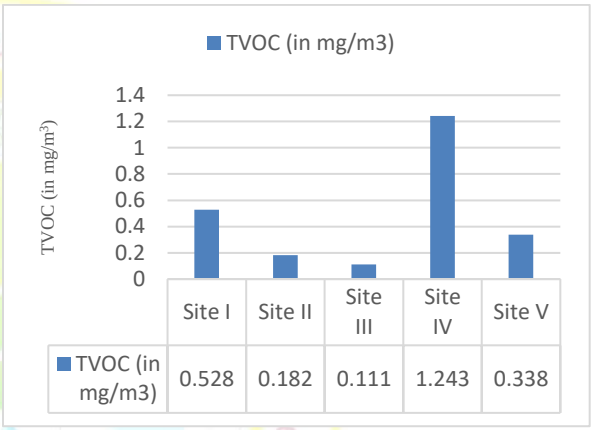

Fig.6: Mean TVOC (in mg/m3) of each site

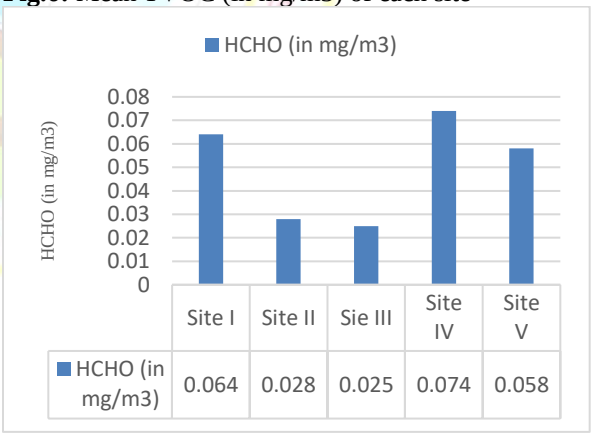

Fig.7: Mean HCHO (in mg/m3) of each site.

The mean PM 2.5 and PM 10 values (in $\mu g/m^3$) range from 32 to 88 (Fig.8) and 36 to 101 (Fig.9) respectively in the selected 5 sites.

Site IV is the most polluted site followed by the site I and site V.

Site III is the least polluted site followed by site II.

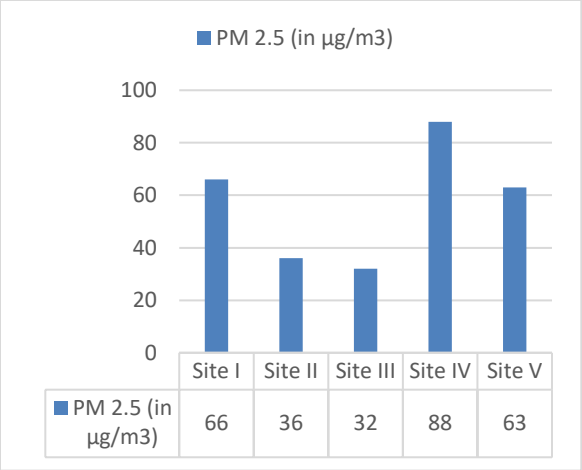

Fig.8: Mean PM 2.5 (in µg/m3) of each site.

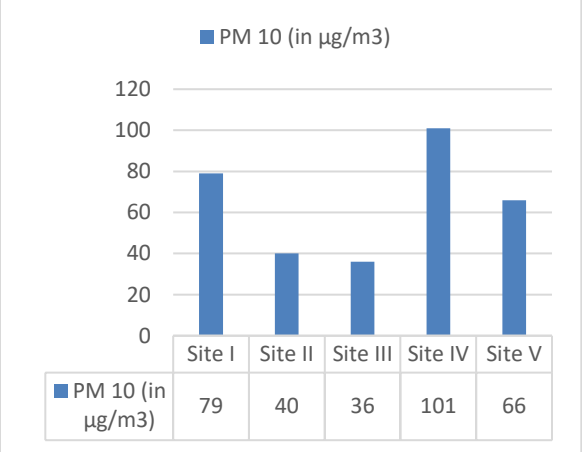

Fig.9: Mean PM 10 (in µg/m3) of each site.

Bird Diversity and Richness

A total of 230 individuals belonging to 10 different families were recorded. The highest number of individuals (i.e., 61) were recorded in site III (least polluted site) followed by site V (i.e., 52 individuals). The least number of individuals was recorded in site II (Table 2). Out of the total birds recorded, birds belonging to 06 different families were common in all 5 sites.

Table 2. A total number of birds of the different families at each site.

Family	Sites					
	I	II	III	IV	V	Total
Sturnidae	17	10	08	12	14	61
Dicruridae	02	03	05	02	03	15
Accipitriformes	06	02	03	06	01	18
Coraciidae	01	03	05	03	04	16
Psittaculidae	00	04	06	04	08	22
Columbidae	05	10	16	12	08	51
Cuculidae	02	01	04	01	03	11
Muscicapidae	03	00	03	02	04	12
Ardeidae	02	00	04	02	02	10
Pycnonotidae	00	00	07	02	05	14
Total	38	33	61	46	52	230

The species richness index ranged between 1.716 (site II) to 2.350 (site IV). For diversity, Shannon-Wiener index values range from 1.68 to 2.16 while the species evenness lies between 0.81 to 0.94. (Table 3).

Table 3: Species richness, Shannon-Wiener index and Species Evenness of each site.

Site	Parameters		
	Species Richness	Shannon-Wiener Index	Species Evenness
I	1.924	1.68	0.81
II	1.716	1.69	0.87
III	2.189	2.16	0.94
IV	2.350	1.99	0.86
V	2.27	2.08	0.90

The study found a moderate negative correlation between the air pollutants (viz., HCHO and PM 2.5) and bird species diversity (Shannon-Wiener diversity index). The negative value of the correlation coefficient marks the inverse relationship between the two variables i.e., with an increase in the value of one variable, the value of the other variable decreases consequently. The degree of relation is featured in Table 4 and Table 5.

Table 4: Correlation coefficient of HCHO with Richness index and Shannon-Wiener Diversity index.

Air Pollutant (HCHO)	Correlation With
Richness Index	r = 0.4784
Shannon-Wiener Diversity Index	r = - 0.0682

Table 5: Correlation coefficient of PM 2.5 with Richness index and Shannon-Wiener Diversity index.

Air Pollutant (PM 2.5)	Correlation With
Richness Index	r = 0.5342
Shannon-Wiener Diversity Index	r = - 0.0976

The study documented the 230 bird individuals of 10 different families across the 5 selected sites of Bilaspur city (Fig.10). The sites with no or less vegetation along with high vehicular traffic have more deteriorated air quality as compared to the sites with moderate to good vegetation cover and less vehicular traffic.

The Shannon-Wiener diversity index shows the high value of bird diversity in a less polluted area and comparatively less diversity of birds in a highly polluted area which shows that the avian community avoids areas with high air pollution and poor air quality. But the evenness of the bird community was not highly affected by the air pollution. The distribution of abundance across the species in a community was nearly the same in all the selected sites. The correlation between the air pollutant (viz., HCHO and PM 2.5) and species richness shows a moderate positive relation which exhibits that change in

air pollutant concentration does not highly affect the richness of the avian community.

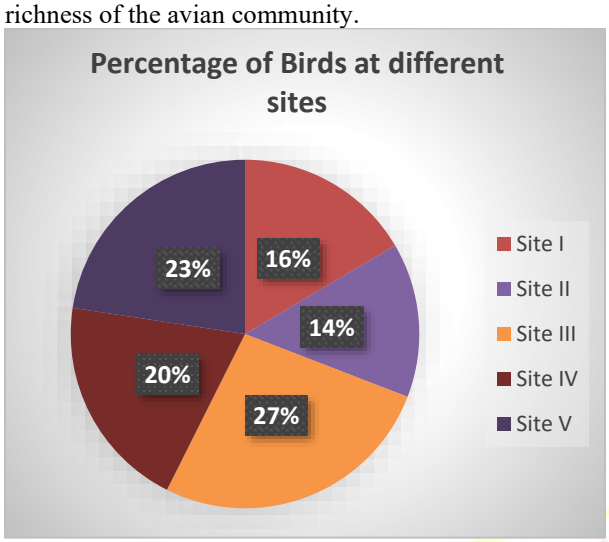

Fig.10. Pie Chart showing percentage composition of birds of different families recorded at each site.

But the major finding of the study shows the negative correlation between the air pollutant (viz., HCHO and PM 2.5) and the bird diversity (Shannon-Wiener diversity index) (Table 4 and Table 5), which indicates that an increase in the concentration of air pollutant of a particular habitat, the diversity of bird species of that habitat decreases and vice versa. A negative correlation denotes the inverse relationship between the two variables, so with the increase in the merit of one variable the merit of the other variable decreases.

Out of the recorded bird species, the birds of 'Ardeidae' family viz., Cattle Egret *(Bubulcus ibis)* and Intermediate Egret *(Ardea intermedia)* were recorded least in the city site followed by the birds of 'Cuculidae' family viz., Asian Koel *(Eudynamys scolopaceus)* and Greater Coucal *(Centropus sinensis)*.

The study also affirms the remarkably high population of birds belonging to 'Sturnidae' family viz. Asian Pied Starling *(Gracupica contra)* and Common Myna *(Acridotheres tristis)* and birds of 'Columbidae' family viz. Rock Pigeon *(Columba livia)*, Laughing Dove *(Spilopelia senegalensis)* and Spotted Dove (*Spilopelia chinensis*) in highly polluted sites. It validates that these bird species have adapted themselves to survive in areas with high air pollution and minimal vegetation. These birds use buildings for roosting, foraging and nesting and are mostly unaffected by noise and human presence, such species can be termed 'Urban Exploiters' (Mohring *et al*., 2021). Avian species which were closely linked to humans like House Sparrow *(Passer domesticus)* and House Crow *(Corvus splendens)* were not recorded in the urban area which could be due to the reason like replacement of natural biotic cover with an artificial substrate like concrete, lawns and asphalt (Turrini *et al*., 2015). The other bird species like Black Kite *(Milvus migrans)*, Indian Roller *(Coracias benghalensis)*, Rose Ring Parakeet *(Psittacula krameri)* and Black Drongo *(Dicrurus macrocercus)* were recorded in adequate numbers throughout the city.

Bilaspur city lacks much green cover and vegetation (Fig.11) due to which less diversity of bird species is observed. With rapid urbanization and industrialization, the air quality of the city is getting worse day by day which is the major reason for the loss of avian diversity in the city (Tiwari *et al*., 2022).

Fig. 11. Map showing the densely populated area of Bilaspur city with a lack of vegetation and greenery.

CONCLUSION

This study was carried out to find out the adverse impacts of air pollution on the diversity of the avian community and also to understand the avian responses towards air pollution by integrating a large number of data sets. Air pollution has a hazardous effect not only on human health but also on the avian community. This study showed the inverse relationship between air pollution and the diversity of birds. The high concentration of pollutants in the air declines the bird diversity of that area. Thus, air pollution must be checked and controlled strongly and positive efforts must be made to enhance the greenery, vegetation cover and biodiversity of the urban area.

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Research Article

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Phytochemical and antibacterial activity of stem bark extract of *Cordia africana* Lam.

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ABSTRACT
Traditional African medicine treats microbiological infections with *Cordia africana*. The maceration method was used to extract powder samples in stages using hexane, chloroform, ethyl acetate and methanol. The presence of carbohydrates, anthraquinones, phenols, proteins, amino acids, saponins, tannins, flavonoids, alkaloids and triterpenoids/steroids were tested in the extracts by conventional phytochemical screening. The study provides evidence-based support for the use of *Cordia africana* by healers in the treatment of microbial diseases and has the potential to be used in medicine.
Keywords: Phytochemical, microorganisms and *Cordia africana*.

INTRODUCTION

The use of plants as healing agents was first discovered in ancient times and is still popular today. The literature on plants with medicinal properties dates back to AD 78 (Alice, 1996). Research has shown that underdeveloped countries, especially in areas where clinics are not readily available, depend mainly on herbal medicines to treat their common ailments (Lambo, 1979). Herbal remedies are commonly used in Japan, China, and the U.K due to the side effects of synthetic drugs and the increased cost of effective drugs (Chin et al., 2006, Rainer et al., 2006, Douglas, 2006). Alkaloids, tannins, flavonoids, saponins, phenolic compounds and others are some of the bioactive antimicrobial components found in plants (Edeogal et al., 2005). When used correctly, bioactive chemicals can treat infections and diseases in humans and animals if carefully extracted, purified and identified. Knowing the chemical composition of any plant is desirable as it can lead to the discovery of new resources from these chemical constituents, as well as the development of therapeutic methods for curing diseases (Sathish et al., 2013). Traditional applications of medicinal plants have gradually developed, resulting in increasingly sophisticated and modern medicines. The type, quality, presentation and idea of the pharmaceutical composition have undergone several adjustments, improvements and newer discoveries (Sathish et al., 2013). The need to reduce the adverse effects frequently associated with the use of synthetic antibiotics and the development of harmful resistant bacteria has increased the search for new effective compounds from plant sources. (Fred, 2006). A genus of flowering plants called Cordia is found in the subfamily Cordioideae of the family Boraginaceae. There are about 2,700 species in the family Boraginaceae, found in tropical, subtropical and warm climates around the world (Gohschling et al., 2003). There are six subfamilies and about 130 genera. Evergreen shrubs and trees of the genus Cordia of the subfamily Cordioideae. There are more than 300 species of Cordia worldwide (Thirupathi et al., 2008). Allilliba, also known as *Cordia africana* lam, is the name of a deciduous tree that can grow up to 30 meters tall and has large, dark green leaves (Bekele - Tesemma et al., 1993). It is a large shade tree that spans about 10 meters. "Gumbail" is the local name in Sudan (ElBein, 1996). In tropical Africa, it is also widely distributed. The tree grows only in the Damazin, Darfor and Kordofan regions of Sudan (Drummond, 1981). Traditional medicine in northern Nigeria uses *Cordia africana* bark powder to relieve pain and inflammation associated with haemorrhoids (personal communication). In East Africa, it is used to treat schistosomiasis, jaundice, and skin problems, and to heal open wounds in general. *Cordia africana* Lam, grown in Egypt, has been the subject of biological and phytochemical investigations, according to Begum et al., (2002). The phytochemical screening results revealed the presence of several components. Using GCMS to analyze the chemical composition of flower essential oils, the percentage of oxidized chemicals in the essential oil was determined (84.16%). When examining the lipoidal content of the leaves, pentanediol was found to be the most abundant hydrocarbon (53.95%). Investigating the carbohydrate

content of *Cordia africana* Lam, the fruit was examined and mannitol was found (27.60%). The fruits' nutritional value was assessed. Fruits are abundant in vitamins, minerals, and total protein. The evaluation of a few phytochemical tests for Gumbail (*Cordia africana*) and its use in termite management is provided by Edeogal et al. (2005). To control termites, the active components from leaves are separated for phytochemical evaluation. This study aimed to identify and identify several phytochemicals found in *Cordia africana* sheep carcass extracts.

MATERIALS AND METHODS

Sample collection and preparation

The stem bark of the plant was collected at Gidan Bubu, a village about 15 kilometres from kwalkwalawa in Wamakko LGA of Sokoto State, Nigeria. The plant was identified and authenticated by Mal Abdulazeez Salihu of the Herbarium section of the botany unit in the Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto with voucher number (UDUH/ANS/0323). The stem bark was air-dried under shade for seven days. This was grounded with the aid of a manual crusher, a Victoria steel hand crusher, to obtain a coarse powder, which was then stored in an air-tight bottle until when required. The chemicals used for this research work were laboratory and analytical-grade reagents. The extraction was performed according to the procedure described by El Mohmood (2009). By placing 300 g of stem bark in a separating funnel with increasing polarity of the solvent, complete extraction was achieved in batches. 1200 Cm^3 n-hexane was applied to the bark of the stem and left for 24 h. Extracts were collected and concentrated using an open space. After drying the residue in the previous step, it was extracted with 1074 cm3 of chloroform as described earlier. The resulting extract was concentrated, and the remainder was further extracted using 1370cm^3 ethyl acetate after being allowed to dry. The extracted material was then concentrated and 1200 cm^3 of methanol was used to remove the remaining material. Formula 1 was used to determine the yield % of the extracts, and the extracts were then separated and stored in sealed containers for future use. Using the agar well dilution method, the antibacterial activity of *C. africana* bark extract was tested against all four microorganisms (El-mohmood, 2009).

Plate 1. *Cordia africana* in its natural habitat

To achieve a concentration of 10 mg/cm^3, each extract was dissolved in 10 cm^3 of dimethylsulfoxide (DMSO). A sterile petri dish is filled with sterilized medium (nutritional agar) (20 ml), covered with a lid, and allowed to cool and solidify. Add 0.1 cm^3 of standard bacterial culture (1.5 x 108 CFU/ml) to the medium, and then allow drying at 390°C for 30 min. Each culture plate has a hollow centre well filled with extracts prepared previously at concentrations of 25, 30, 35 and 40 mg/ml using a standard cork borer (6 mm diameter). The control of ciprofloxacin was performed by the same method (positive control).

$$\%\ \boldsymbol{yield} = \frac{\boldsymbol{weight\ of\ extract\ obtained}}{\boldsymbol{weight\ of\ sample}} \times \frac{\mathbf{100}}{\mathbf{1}} \quad \ldots\ldots (1)$$

RESULTS AND DISCUSSION

The results of the experiment carried out are given in the Tables below.

Phytochemical Screening

The result of the phytochemical screening is supplied in table 1 below. The methanol extract incorporates all the phytochemicals screened and is then followed by way of ethyl acetate which no longer incorporates alkaloids. The n-Hexane extract incorporates only steroids and Triterpenoids. The chloroform extract contains steroids/Triterphenoids and carbohydrates. Anthraquinones is absent in all of the extracts.

Table 1. Preliminary Phytochemical Screening of *Cordia africana* extracts

Test/ Phytochemical	n- Hexane	Chloroform	Ethyl acetate	Methanol
Alkaloid				
Meyer test	-	-	-	-
Wagner test	-	-	-	+
Dragendorff test	-	-	-	+
Hager test	-	-	-	+
Carbohydrate				
Molish's test	-	+	+	++
Fehling test	-	+	+	++
Saponins				
Frothing test	-	-	-	+
Flavonoids				
Shinodas test	-	-	+	+

Ferric chloride	-	-	+		-
NaOH	-	-	+		+
Tannins					
Ferric chloride	-	-	+	+	
Lead- sub acetate	-	-	+		+
Phenols					
Ferric chloride	-	-	+	-	
Protein and amino acid					
Xanthoproteic test	-	-	-		+
Triterphenoids/ steroids					
Salkowski test	++	++	++		++
Leiberrmann burchard test	++	++	++		++
Anthraquinones	-	-	-	-	

Key: - = absent, + = present, and ++= appreciable amount

Antimicrobial Screening

The effects of the antimicrobial research are provided in table 2 and Plate 2. the n- Hexane inhibited all of the microorganisms except *B. subtilis*. The chloroform extract did not inhibited any of the microbes. The ethyl acetate extract is more on *S. aureus* with the region of inhibition of 8.0mm. The methanol extract inhibited all except boom of *E. coli* best.

Table 2. Zone of inhibition in millimetres (mm)

Micro Organism	mg/ml	n- Hexane	Chloroform	Ethyl acetate	Methanol
Staphylococcus aureus	25	2.0	-	2.0	-
	30	2.0	-	2.1	-
	35	4.0	-	3.0	-
	40	5.0	-	8.0	-
Escherichia coli	25	1.0	-	-	1.5
	30	2.0	-	-	2.0
	35	2.1	-	-	3.0
	40	3.0	-	-	3.5
Bacillus subtilis	25	-	-	-	-
	30	-	-	-	-
	35	-	-	-	-
	40	-	-	-	-
Pseudomonas aeruginosa	25	2.0	-	-	-
	30	2.1	-	-	-
	35	3.0	-	-	-
	40	5.0	-	-	-

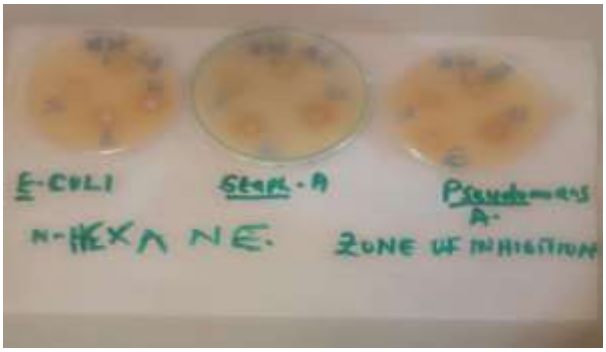

Plate 2. Anti-bacterial activity of the extracts on microorganisms

Thin Layer Chromatography

Thin-layer chromatography was done using silica gel (GF254 nm) and many mobile phases were tested. The best separation was observed with mobile phase (n-Hexane: Ethyl acetate) (99: 1). The TLC Plate of the ethyl acetate showed six spots. The R_F value of each spot is presented in Table 4 and Plate 3.

Table 3. Standard antibiotic on test microorganism zone of inhibition of ciprofloxacin (control)

Microorganism	Zone of inhibition in millimetres (mm)
Staphylococcus aureus	10.0
Escherichia coli	12.0
Bacillus subtilis	1.0
Pseudomonas aeruginosa	14.0

Table 4. Table of R_F values of TLC viewed under UV-light at 254nm.

Pooled Eluate	R_F value
A	0.56
B	0.03
C	0.41
D	0.45
E	0.04
F	0.62

Table 5. Showing n-Hexane: Ethyl acetate solvent profile during column chromatography

n-Hexane:		Ethyl acetate
99	:	1
94	:	6
93	:	7
92	:	8
92	:	8
90	:	10
89	:	11
88	:	12

Antimicrobial Activity of Isolate (A)

The results are offered in table 6. The isolate shows strong antimicrobial activity on E. coli and B. subtilis.

Table 6. Zone of inhibition recorded against pure sample on microbes

Microorganism	Zone of inhibition in millimeters (mm)
Staphylococcus aureus	5.0
Escherichia coli	22.0
Bacillus subtilis	16.0
Pseudomonas aeruginosa	7.0

Fourier Transform Infrared Spectroscopy (FTIR)

The results are presented in Table 7. The spectrum showed frequencies corresponding to the functional group in the isolate.

Table 7. FTIR Result of Isolate (A)

Frequency (cm-1) Literature	frequency (cm-1) Sample	intensity	assignment	functional group
675 – 900	837.13	63.93	C – H Aromatic	ester Aromatic
650 – 1000	945.15(w)	60.76	C – H bending	1,2,4 – tri substituted
	968.30(w)	61.57	C – H bending	1,2-disubstituted
1000 – 1300	1168.90(w)	59.86	C – O stretching	ester, carboxylic acid
1000 – 1750	1743.71(m)	53.98	C = O stretching	carboxylic acid and its derivative
3100 – 3000	3055.35	57.41	= C – H stretching	Alkene
1600 – 1475	1446.66	62.07	– C = C	Aromatic
3075 – 3095	3055.35	57.41	– C = C	Alkene substitution
2850 – 3000	2924.18 (s)	45.51	CH_3,CH_2,CH	Alkanes

Key: Where (m) – medium peak, s – strong peak, w – weak peak

GC-MS

The GC-MS revealed the presence of some compounds.

The results showed the molecular ion peak of various compounds as presented in Table 8,

Table 8. GC-MS Analysis Result

Peak No	Retention time	Compound name	Molecular Base formula	peak	Molecula ion peak
1	16.793	isobutyloctadecylester	$C_{30}H_{50}O_4$	149	419
2	17.127	butyl undecyl ester	$C_{23}H_{36}O_4$	149	321
3	20.417	methyl – 12- oxo-9-dodecanoate	$C_{13}H_{22}O_3$	55	226

Fig 1: Isobutyloctadecylester`

Fig 2: butylundecylester`

The plant material was subjected to serial exhaustive extraction by maceration using solvents of increasing polarity, n- Hexane, Chloroform, Ethyl acetate and Methanol. Table 1 shows the various phytochemicals present. However, the result shows the absence of anthraquinone. extracts were tested against two Gram-positive (*S. aureus* and *B. subtilis*) and two Gram-negative (*E. coli* and *P. aeruginosa*) bacteria. Diameters of zones of inhibition for different fractions against standard organisms are shown in Table 2. Ethyl acetate fraction showed activity ranged between 2.0 -8.0 mm, n-Hexane shows activity between 2.0 -5.0 mm while methanol shows activity between 1.5 -3.5 mm. The highest zone of inhibition by the standard ciprofloxacin was against *P. aeruginosa* with diameter of 14.0 mm. the chloroform extract does not show any activity on any of the bacterial. This is in agreement with similar work on *Cordia africana* (Emtinan *et al*., 2015). Thin layer chromatography was done using of silica gel (GF254 nm) and many mobile phases were tested. The best separation was observed with mobile phase (n- Hexane: Ethyl acetate) (99: 1). The fraction showed the presences of six florescence spots with different RF values when inspected under UV lamps (254 nm). The Plate after being sprayed with Para anisaldehyde spray reagent gave six spots, RF values of separated spots ranged between 0.03 and 0.62 and the colours were grey, violet, pale violet, green and blue. Colours of separated spots indicate that a fraction may contain triterpens, sterols, sugars and phenols. Table 5 shows results of column chromatography. A total of 97 fractions obtained and pooled together based on their thin layer chromatography (TLC) profile, gave six combined sub-fractions (A–F) as shown in the Table. Sub-fraction A, with an R_F of 0.56 (80:20 H: E), appeared to be a pure compound, whereas sub-fractions B–F were mixtures of various compounds as revealed on their TLC plates. Since our interest is on obtaining a pure isolate,

Sub fraction A that shows a single spot was further subjected to anti-bacterial activity using the same stock culture of a clinical isolate of two-gram positives, *Staphylococcus aureus* and *Bacillus subtilis* and two-gram negatives, *Escherichia coli* and *Pseudomonas aeruginosa* with the same procedure. An improved zone of inhibition was noticed in all four bacterial except *Staphylococcus aureus*. *Escherichia coli* showing the highest zone of inhibition of 22.0 mm, greater than that recorded for ciprofloxacin. Another point of interest is that *Bacillus subtilis*, that shows no activity with ethyl acetate extract and very low activity with ciprofloxacin, show improved activity on Isolate A. However, *Staphylococcus aureus* with the highest activity of 8.0 mm on ethyl acetate shows a lesser activity of 5.0 mm. Thus, it is plausible that the disparity in the antimicrobial activity observed in this study shows that Isolate A recorded a higher antibacterial activity as against the initial extract obtained from the various solvents. It is also observed that there is a general increase in the zone of inhibition with an increase in the solvent concentration. The FTIR spectrum of Isolate A as shown in Table 7 indicates the presence of aliphatic C-H stretching vibration at 2924 cm^{-1}, C = O stretch at 1743.71 and 1168.90 cm^{-1} respectively and C = C stretch of aromatics and aliphatics at 1446.66 and 1168.90 cm^{-1} respectively. The presence of C= C double bond between 1600 and 1475 is mainly unique to compounds with an aromatic ring. The presence of C- O stretching vibration at 1168.90 further indicates the presence of aromatic ester.

The GC-MS results as shown in Table 8 indicate the presence of three compounds. These compounds include isobutyl undecyl ester, butyl undecyl ester and methyl–12-oxo-9- dodecanoic. The result is in agreement with our FTIR result which shows the functional group of ester in the spectrum. These compounds are in agreement with some previous work on the plant *Cordia*. (Adeleke *et al*., 2015). However, the GC-MS revealed that the isolate could no longer be said to be a pure compound but rather a mixture of three compounds.

CONCLUSION

Phytochemical potentials of the stem bark of *Cordia africana* have been evaluated in this research and it revealed the presence of phytochemicals, such as Alkaloids, Carbohydrate, Saponins, Flavonoids, Tannins, and Triterpenoids. Result obtained at various concentration of the extract s, indicated that the Ethylacetate extracts possesses the highest antibacterial activity on tested bacteria, and one of its column chromatographic fraction showed high activity against *E. coli.* The TLC profile was used to determine the column chromatography of the fraction in which 97 eluents obtained were pooled together to obtain six sub-fractions (A-F), where fraction A Appear as a pure isolate. Isolate A shows a stronger antibacterial activity than the initial extract as revealed in table 6. However, upon FTIR and GC-MS analysis, the isolate through the GC-MS chromatogram revealed the following compounds; Isobutyloctadecylester, Butyl undecyl ester and Methyl-12-oxo-9-dodecanoate.

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Research Article

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Effect of organic manures and biofertilizers on growth and yield of watermelon (*Citrullus lanatus* Thunb.)

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ABSTRACT
A field experiment entitled "Effect of organic manures and biofertilizers on growth and yield of watermelon *(Citrullus lanatus* Thunb.)" was conducted at Instructional Farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during summer season of 2019 - 2020. The experiment was laid out in Randomized Block Design (RBD) with three replications and nine treatments viz.T1 (Farm Yard Manure @ 40 t ha^{-1}), T2 (Compost (NADEP) @ 18 t ha^{-1}), T3 (Vermicompost @ 13.5 t ha^{-1}), T4 (Poultry manure @ 6.6 t ha^{-1}) and T5 (Farm Yard Manure @ 40 t ha^{-1} + Soil application of *Azotobacter*+ PSB @ 5 kg ha^{-1} each), T6 (Compost (NADEP) @18 t ha^{-1} + Soil application of *Azotobacter*+ PSB @ 5 kg ha^{-1} each), T7 (Vermicompost @ 13.5 t ha^{-1} + Soil application of *Azotobacter*+ PSB @ 5 kg ha^{-1} each), T8 (Poultry manure @ 6.6 t ha^{-1} + Soil application of *Azotobacter*+ PSB @ 5 kg ha^{-1} each), T9 Control (RDF- 200:100:100 NPK Kg/ha). The various observations in respect of vine growth and yield of watermelon were recorded periodically. From the present findings, it was observed that the growth parameters in respect length of main vine, number of leaves, number of primary branches, chlorophyll index, days for first female flower appearance, internodal distance and male female ratio were found better with Vermicompost @ 13.5 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each. Yield parameters viz days required for edible maturity, number of fruits per vine, average fruit weight kg, fruit yield kg per vine and fruit yield per ha^{-1} (tons) were found to be maximum with Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each.
Keywords: Watermelon, Compost, Poultry manure, Farm yard manure, Azotobacter, PSB, Growth, Yield.

INTRODUCTION

Cucurbits were among the first group of plants used by man. They include dessert salad, pickling and culinary types. Among the dessert type, watermelon is the most important crop in the tropical regions of the world. Wa termelon (*Citrullus lanatus* Thunb.) is an important cucurbitaceous vegetable. It is known as tarbuj, tarmuj, kalinda and kalingad in different parts of India. An excellent desert fruit, it is relished by rich as well as poor. The fruit contain 92% water, 0.2% protein, 0.3% minerals, and 7% carbohydrate in 100 g edible flesh. The fruit juice makes an excellent refreshing and cooling beverage. Watermelon is a rich source of citrulline, an amino acid that can be metabolized to arginine, an essential amino acid. Watermelon (*Citrullus lanatus* Thunb.) is believed to have originated in Africa and spread to other parts of world. In India current status of area is 110 mha. With production 2787 MT (NHB database 2019-20). In India Uttar Pradesh is first in area and production and Maharashtra is with area 6.12 mha and at 10^{th} in production i.e 46.99 MT.

Organic manures are effective source of nitrogen for sustainable crop production, the manure application enhances soil productivity, increases the soil organic carbon content, soil micro-organisms, improves soil crumb structure, the nutrient status of the soil and enhances crop growth and yield. In order to improve soil health and to keep the soil sustainable for a long-time addition of organic sources play an important role. In this context biofertilizers which contain ecofriendly, agriculturally beneficial microorganisms help in enriching the soil with nutrients to maintain the soil fertility and supplies essential nutrients for crop growth. Organic manures are essential for obtaining optimum production, productivity and good quality of Watermelon. Amongst the cultural practices organic manures has a greater significance for better productivity of watermelon. Different organic manures may have better effect on growth, yield and quality of watermelon. Biofertilizers may result in more vegetative growth and increases the availability of soil nutrients. However due to suitable combination of organic manures and biofertilizers may have better effect on yield per unit area may be increased. Thus, application of different organic manures and biofertilizers influences growth per unit

area under same variety which results in variation in growth and yield of watermelon.

Hence considering above facts the present investigation is aimed to find out a suitable combination of organic manures and biofertilizers, their effect on the growth and yield of organic watermelon cultivation.

MATERIALS AND METHODS

The field experiment entitled "Effect of organic manures and biofertilizers on growth and yield of watermelon *(Citrullus lanatus* Thunb.)" was conducted at Instructional Farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during summer season of 2019 - 2020. The experiment was laid out in Randomized Block Design (RBD) with three replications and nine treatments viz.T1 (Farm Yard Manure @ 40 t ha^{-1}), T2 (Compost (NADEP) @ 18 t ha^{-1}), T3 (Vermicompost @ 13.5 t ha^{-1}), T4 (Poultry manure @ 6.6 t ha^{-1}) and T5 (Farm Yard Manure @ 40 t ha^{-1} + Soil application of *Azotobacter*+ PSB @ 5 kg ha^{-1} each), T6 (Compost (NADEP) @18 t ha^{-1} + Soil application of *Azotobacter*+ PSB @ 5 kg ha^{-1} each), T7 (Vermicompost @ 13.5 t ha^{-1} + Soil application of *Azotobacter*+ PSB @ 5 kg ha^{-1} each), T8 (Poultry manure @ 6.6 t ha^{-1} + Soil application of *Azotobacter*+ PSB @ 5 kg ha^{-1} each), T9 Control (RDF- 200:100:100 NPK Kg/ha).

The data obtained on various characters were statistically analyzed by Randomized Block Design by Panse and Sukhatme (1967). Critical difference for examining treatment means for their significance was calculated at 5 % level of significance.

RESULTS AND DISCUSSION

Length of main vine (cm) as influenced by organic manures and biofertilizers in watermelon:

The data regarding length of main vine (cm) as influenced by organic manures and biofertilizers were recorded at 30, 60, 90 DAT presented in table no. 1 The growth parameters like length of main vine was maximum throughout the growth period (58.80 cm, 176.63 cm and 246.17 cm at 30, 60, 90 DAT respectively) in treatment T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). Whereas minimum length of main vine was recorded (47.19 cm, 159.98 cm and 229.94 cm) in T_4 (Poultry manure @ 6.6 t ha^{-1}) at 30, 60, 90 DAT respectively. The results of present investigation are in agreement with the findings of Tahir *et al.* (2018) in watermelon, Kucinkas *et al*. (2000), Atiyeh *et al.* (2002) and Bindiya *et al.* (2014) in cucumber.

Number of leaves as influenced by organic manures and biofertilizers:

The data presented in table no. 1 indicated that, the differences in number of leaves influenced by organic manures and biofertilizers were found to be significant at all the stages of growth i.e., 30, 60 and 90 DAT. At 30 DAT, maximum number of leaves per vine (30.37, 152.86 and 242.67) were observed in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each) at 30, 60 and 90 DAT respectively. Whereas, minimum number of leaves per vine (26.16, 140.20 and 229.53) were observed in treatment T_1 (Farm Yard Manure @ 40 t ha^{-1}). It is well evident from the data that, use of vermicompost produced significantly a greater number of leaves per vine than other manures. This might be due to the fact that Vermicompost gave an opportunity for more availability of nutrients, moisture for development of a greater number of leaves. Similar results were also reported by Tahir *et al.* (2018) in watermelon, Kucinkas *et al*. (2000), Atiyeh *et al.* (2002) and Bindiya *et al.* (2014) in cucumber.

Number of primary branches influenced by organic manures and biofertilizers:

The data regarding number of primary branches as influenced by organic manures and biofertilizers were recorded and presented in table no. 1 maximum number of primary branches (3.79, 6.60 and 8.89) were observed in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each) at 30, 60 and 90 DAT respectively. Whereas, minimum number of primary branches (2.33, 4.60 and 6.64) were observed in T_4 (Poultry manure @ 6.6 t ha^{-1}). These results are in the line with the findings of Tahir *et al.* (2018), Bindiya *et al*. (2014) in cucumber.

Internodal distance (cm) influenced by organic manures and biofertilizers:

The data regarding internodal distance (cm) as influenced by organic manures and biofertilizers were recorded and presented in table no. 2 the minimum internodal distance (5.17cm) was observed in treatment T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). Whereas maximum internodal distance was observed (6.36 cm) in treatment T_4 (Poultry manure @ 6.6 t ha^{-1}) at 60 DAT respectively. These results are in the agreement with the findings of Anita and Elham (2015) in pumpkin.

Chlorophyll index influenced by organic manures and biofertilizers:

The data presented in table no. 2 indicated that, the differences in chlorophyll index of leaves as influenced by different organic manures and biofertilizers was found to be significant. The maximum chlorophyll index was observed (60.39 and 60.48) in treatment T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). at 45 and 60 DAT respectively. Whereas the minimum chlorophyll index (59.31 and 59.37) was observed in treatment T_1 (Farm Yard Manure @ 40 t ha^{-1}). It is observed from the data that chlorophyll index significantly maximum with Vermicompost + soil application of Azotobacter +PSB. These results are in accordance with the results reported by Tahir *et al.* (2018), Azarmi *et al*. (2009) in cucumber.

Table 1. Length of main vine (cm), number of leaves and number of primary branches as influenced by organic manures and biofertilizers in watermelon

Treatments	Length of main vine(cm)			Number of leaves			Number of primary branches		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1- Farm Yard Manure @ 40t ha-1	48.40	164.40	230.60	26.16	140.20	229.53	2.66	4.90	6.91
T_2-Compost (NADEP) @ 18 t ha-1	49.68	165.48	230.68	27.22	143.86	232.40	2.70	5.22	6.98
T_3-Vermicompost @ 13.5 t ha-1	50.52	170.10	231.86	28.13	144.80	234.13	2.80	5.43	7.17
T_4-Poultry manure @ 6.6 t ha-1	47.19	159.98	229.94	27.02	141.93	231.80	2.33	4.60	6.64
T_5- Farm Yard Manure @ 40t ha-1 + soil application of Azotobacter +PSB @ 5kg ha-1 each	54.67	169.37	239.2	29.10	146.66	240.07	3.07	6.12	8.18
T_6- Compost (NADEP) @ 18 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each	56.00	172.75	241.53	30.19	151.66	241.53	3.56	6.30	8.81
T_7- Vermicompost @ 13.5 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each	58.80	176.63	246.17	30.37	152.86	242.67	3.79	6.60	8.89
T_8- Poultry manure @ 6.6 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each	50.10	167.03	237.56	28.19	146.00	237.20	2.90	5.87	7.42
T_9-Control (RDF-200:100:100 NPK kg ha-1)	51.12	163.39	238.30	30.07	147.33	240.27	2.96	5.90	7.69
'F test'	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E.(m)±	1.72	3.82	4.01	0.98	3.06	3.13	0.19	0.36	0.48
CD at 5 %	5.19	11.48	12.02	2.95	9.20	9.34	0.57	1.07	1.45

Table 2. Internodal distance (cm) 60 DAT, chlorophyll index (SPAD value), node at which first female flower appeared and days to first female flower appearance as influenced by organic manures and biofertilizers in watermelon.

Treatments	Internodal distance (cm)	Chlorophyll index (SPAD value)		Node at which first female flower appeared	Days to first female flower appearance
	60 DAT	45 DAT	60 DAT		
T_1- Farm Yard Manure @ 40t ha-1	6.29	59.31	59.37	10.88	40.69
T_2-Compost (NADEP) @ 18 t ha-1	6.13	59.78	59.83	10.21	40.34
T_3-Vermicompost @ 13.5 t ha-1	5.9	60.03	60.1	9.25	39.33
T_4-Poultry manure @ 6.6 t ha-1	6.36	59.73	59.81	9.74	39.74
T_5- Farm Yard Manure @ 40t ha-1 + soil application of Azotobacter +PSB @ 5kg ha-1 each	5.84	60.09	60.19	9.83	39.99
T_6- Compost (NADEP) @ 18 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each	5.58	60.26	60.32	8.37	37.8
T_7- Vermicompost @ 13.5 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each	5.17	60.39	60.48	7.6	37.72
T_8- Poultry manure @ 6.6 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each	6.1	60.16	60.25	8.58	38.03
T_9-Control (RDF-200:100:100 NPK kg ha-1)	5.7	60.36	60.39	9.1	38.58
'F test'	Sig.	Sig.	Sig.	Sig.	Sig.
S.E.(m)±	0.24	0.19	0.21	0.6	0.65
CD at 5 %	0.72	0.57	0.63	1.8	1.94

Male female ratio influenced by organic manures and biofertilizers:

The data regarding to the male female flower ratio as influenced by organic manures and biofertilizers was recorded at flowering stage and presented in table no. 2 maximum male female ratio was observed (6.97) in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). Whereas minimum male female ratio was observed (4.57) in T_4 (Poultry manure @ 6.6 t ha^{-1}). These results are in the agreement with the findings of Anita and Elham (2015) in pumpkin.

Node at which first female flower appearance influenced by organic manures and biofertilizers.

The data regarding node at which first female flower appeared as influenced by organic manures and biofertilizers were recorded and presented in table no. 2 node at which first female flower appearance was observed (7.60) in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). Whereas first female flower appearance at longest node was observed (10.88) in T_1 (Farm Yard Manure @ 40 t ha^{-1}). These results are supported by the findings of Tahir

et al. (2018) in watermelon and Karuthamam *et al*. (1995) in pumpkin.

Days for first female flower appeared influenced by organic manures and biofertilizers:

The data regarding days for first female flower appearance as influenced by organic manures and biofertilizers were recorded and presented in table no. 2 minimum days for first female flower appeared was observed (37.72) in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). Whereas maximum days for first female flower appeared was observed (40.69) in T_1 (Farm Yard Manure @ 40 t ha^{-1}). These results are in agreement with the results of Tahir *et al.* (2018) in watermelon and Karuthamam *et al*. (1995) in pumpkin.

Effect of organic manures and biofertilizers on yield attributes of watermelon:

Days required for edible maturity as influenced by organic manures and biofertilizers in watermelon.

The data regarding days required for edible maturity as influenced by organic manures and biofertilizers was recorded and depicted in table no. 3 minimum days required for edible maturity (74.63) was recorded in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). Whereas, maximum days required for edible maturity (77.68) was recorded in T_1 (Farm Yard Manure @ 40 t ha^{-1}).

Number of fruits per vine as influenced by organic manures and biofertilizers in watermelon:

The data regarding number of fruits per vine as influenced by organic manures and biofertilizers was recorded and presented in table no. 3 maximum number of fruits vine (3.71) was recorded in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). Whereas, minimum number of fruits vine (2.93) was recorded in T_1 (Farm Yard Manure @ 40 t ha^{-1}). Similar results were found with the findings of Chinanshuk *et al*. (2016) in watermelon and Rasool *et al*. (2009) in cucumber.

Average fruit weight (kg) as influenced by organic manures and biofertilizers:

The data regarding average fruit weight as influenced by organic manures and biofertilizers was recorded and presented in table no. 3 maximum average fruit weight (3.73 kg) was recorded in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). Whereas, minimum average fruit weight (3.04 kg) was recorded in T_1 (Farm Yard Manure @ 40 t ha^{-1}). These results were recorded with the findings of Chinanshuk *et al*. (2016) and Ceren *et al.* (2021) in watermelon.

Fruit yield per vine (kg) as influenced by organic manures and biofertilizers:

The data regarding fruit yield per vine (kg) as influenced by organic manures and biofertilizers were recorded and presented in table no. 3 maximum fruit yield kg per vine (13.83 kg) was recorded in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). Whereas minimum fruit yield kg per vine (8.90 kg) was recorded in treatment T_1 (Farm Yard Manure @ 40 t ha^{-1}). Similar results were found with the findings Muzeev *et al*. (2019) and Rasool *et al*. (2009) in cucumber.

Fruit yield per hectare as influenced by organic manures and biofertilizers:

The data on total fruit yield per hectare as influenced by organic manures and biofertilizers was recorded and presented in table no. 3 data indicated significant differences among the treatments. The maximum fruit yield ha^{-1} (87.68 tons) were recorded in T_7 (Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each). While T_1 (Farm Yard Manure @ 40 t ha^{-1}) recorded minimum fruit yield ha^{-1} (56.42 tons). These results are in accordance with the findings Muzeev *et al*. (2019) in watermelon and Anita *et al.* (2003), Rasool *et al*. (2009) in cucumber.

Table 3. Days required for edible maturity, number of fruits per vine, average fruit weight (kg) and yield (tons) ha^{-1} as influenced by organic manures and biofertilizers in watermelon.

Treatments	Days required for edible maturity	Number of fruits per vine	Average fruit weight (kg)	Yield (tons) ha^{-1}
T_1- Farm Yard Manure @ 40t ha-1	77.68	2.93	3.04	56.42
T_2-Compost (NADEP) @ 18 t ha-1	76.26	3.2	3.42	69.35
T_3-Vermicompost @ 13.5 t ha-1	76.41	3.33	3.51	74.05
T_4-Poultry manure @ 6.6 t ha-1	77.12	3.21	3.47	70.56
T_5- Farm Yard Manure @ 40t ha-1 + soil application of Azotobacter +PSB @ 5kg ha-1 each	76.38	3.13	3.21	63.65
T_6- Compost (NADEP) @ 18 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each	75.07	3.69	3.61	84.44
T_7- Vermicompost @ 13.5 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each	74.63	3.71	3.73	87.68
T_8- Poultry manure @ 6.6 t ha-1+ soil application of Azotobacter +PSB @ 5kg ha-1 each	75.53	3.67	3.59	83.49
T_9-Control (RDF-200:100:100 NPK kg ha-1)	74.78	3.43	3.68	80.01
'F test'	Sig.	Sig.	Sig.	Sig.
S.E.(m)±	0.5	0.11	0.14	2.37
CD at 5 %	1.5	0.34	0.43	7.12

CONCLUSION

On the basis of present findings, it can be concluded that, effect of organic manures and biofertilizers has influenced the growth and yield parameters of watermelon. Regarding the growth parameters, in respect of length of main vine, number of leaves, number of primary branches, chlorophyll index, days for first female flower appearance, internodal distance and male female ratio were found better with Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each. Yield parameters viz days required for edible maturity, number of fruits per vine, average fruit weight kg, fruit yield kg per vine and fruit yield per ha^{-1} (tons) were found to be maximum with Vermicompost @ 13.5 t ha^{-1}+ soil application of *Azotobacter* +PSB @ 5kg ha^{-1} each.

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Research Article

OPEN ACCESS

Response of grafts of different scion varieties on the different rootstock of mango (*Mangifera indica* L.) under nursery conditions

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ABSTRACT

The investigation was carried out at the College of Horticulture, Bidar to study the "Performance of grafts of different scion varieties on the different rootstock of mango (*Mangifera indica* L.) under nursery conditions" with thirty-six treatments comprising of twelve rootstocks (Kurukkan, Kitchner, Olour, EC-95862, Kensington, Peach, Nekkare, Muvandan, Bappakai, Mylepelian, Starch and Local) and three scions (Baneshan, Dashehari and Kesar). Among different rootstocks, Nekkare registered minimum days for sprouting, maximum sprout length, graft success, the height of grafted plant and number of leaves per graft (12.47 days, 6.08 cm, 89.17%, 29.4 cm and 18.33 respectively) whereas the maximum scion girth and root-collar diameter was registered with Bappakai (5.67 and 6.57mm respectively). In scion varieties Kesar recorded minimum days for the emergence of sprouts (15.92 days), maximum sprout length (5.39 cm), graft success (85.83 %), the height of grafted plant (26.74 cm), scion girth (5.55 mm) and root-collar diameter (6.51mm). In the case of different rootstock scion combinations, Nekkare grafted with Kesar recorded a minimum number of days taken for sprouting (11.4 days), maximum sprout length (7.15 cm), graft success (95 %), the height of grafted plant (33.55 cm) and several leaves per graft (19.7) whereas, scion girth and root-collar diameter were found non-significant.

Keywords: Rootstock, Scion, Stionic combination, mango, grafting success.

INTRODUCTION

Mango belongs to the family Anacardiaceae with having chromosome number of 2n=40. Mango is native to the Indo-Burma region and is a centre of origin of mango. The fruit is widely accepted as the king of fruit by knowing its adaptability and nutritional value. Hence, In India, It has the privilege of being 'National fruit. The fruit is being utilized at every developmental stage for one or another purpose like pickling and table purpose. Further, ripe fruits are utilized for preparing fresh invigorating and refreshing drinks. In India mango leads in production and area. leads with an area of 23.13 lakh ha and in production with 223.53 lakh tonnes (Anon., 2019). It is grown in almost all states of India. Andhra Pradesh stands first in the area with 3.33 lakh ha and second in production with 45.40 lakh tonnes (Anon., 2019).

However, from the nursery perspective of raising mango plant saplings, farmers and nurserymen raise through stones due to its highly cross-pollinated nature; wide variability exists in the progeny and is a limitation for commercial orcharding.

The plant takes 8-10 years for fruiting and the canopy of the plant to become large. But moving up in the technology of multiplication, now it has become simple to multiply mango by different vegetative grafting methods. The original superior mango varieties of seed origin still exist in various parts of the country but the occurrence of promising types is frequent as mango is cross-pollinated. To obtain true-to-type progeny and to establish uniformity in plant growth, there is a need to propagate mango by vegetative means.

To obtain successful graft union, rootstocks must be strong, healthy and vigorous (Patel et al. 2017) and such rootstock shows a greater effect on production efficiency and yield. However, the stionic relationship is very important for the production of the vegetative method of propagation. If the rootstock is from a tall plant and the scion is from a dwarf plant or vice versa, the graft union may occur but the growth of both stock and scion may not be uniform. The difference in uniformity may affect the growth and development of plants (Bhuiyan et al. 2010).

Increasing demand for the best planting material, there is a necessity to raise a seedling/rootstock, to ensure higher graft success, better growth and stem girth, along with good field establishment.

MATERIALS AND METHODS

Description of the experiment

The investigation was conducted at College of Horticulture, Bidar which is situated in North-Eastern transitional zone of Karnataka (Zone- I) located at 17^0 53' North latitude, 77^0 32' East longitude and at an altitude of 576.28 m above the mean sea level during 2019-2020 to study the performance of grafts of different scion varieties on the different rootstock of mango (*Mangifera indica* L.) under nursery conditions with thirty-six treatments comprising of twelve rootstocks (Kurukkan, Kitchner, Olour, EC-95862, Kensington, Peach, Nekkare, Muvandan, Bappakai, Mylepelian, Starch and Local) over three scions (Baneshan, Dashehari and Kesar) varieties. In this context, the experiment was carried out using a factorial randomized complete block design with two replications. The following observations were recorded for sprouting, sprout length (cm) at 15, 30 and 45 DAG, graft success (%) at 15, 30 and 45 DAG, the height of grafted plant (cm) at15, 30 and 45 DAG, scion girth (mm) at 30, 60 and 90 DAG, root-collar diameter (mm) at 30, 60 and 90 DAG and number of leaves per graft at 30, 60 and 90 DAG were recorded.

Statistical analysis

The data recorded on graft parameters were subjected to Fisher's method of analysis of variance and the interpretation of data was done as given by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The results of the performance of the plants produced by veneer grafting with different rootstock-scion combinations have been presented and discussed. The results of different graft parameters have been discussed.

3.1. Number of days taken for the emergence of sprouts

Among different rootstocks and scion varieties, Nekkere (R_7) (12.47 days) and Kesar (15.92 days) recorded a minimum number of days for the emergence of sprouts respectively. In the case of different treatment combinations, the lowest number of days for the emergence of sprouts (11.40 days) was registered in R_7S_3 (Nekkere + Kesar) and the highest was registered with R_5S_2 (Kensington + Dashehari) (21.30 days) and $R_{11}S_2$ (Starch + Dashehari) (21.30 days). This wide variation might be due to differences in the vigour of various rootstocks and the heterozygous nature. The ideal relative humidity and temperature also play a crucial role in the early emergence of sprouts by avoiding the drying up of buds and inducing sap flow in grafts. Similar results were documented by Jana (2007) in mango and Somkuwar *et al*. (2009) in grapes.

Sprout length

The rootstock R_7 (Nekkere) (6.08 cm) and scion variety S_3 (Kesar) (5.39 cm) registered the highest sprout length at 45 days after grafting. Among different interaction effects, the treatment combination R_7S_3 (Nekkere + Kesar) registered the highest sprout length (7.15 cm). This maximal sprout length might be due to better initial graft union formation, the vigorous activity of vascular cambium and proper healing of union which helped in early sprouting. Similar results were documented by Satisha et al. (2004) in grapes.

Graft success

The rootstock Nekkere (R_7) (89.17 %) and scion variety Kesar (S_3) (85.83 %) registered the maximal graft success. The interaction effect of rootstocks and varieties was not influenced for graft success. This divergence in the rate of graft success might be due to prevailing temperature (minimum, optimum and maximum), relative humidity and also genetic variations influencing histological and physiological developments within the shoots (Maiti and Biswas, 1980). Findings are in confirmation with Chandrashekar (1982) in mango, Veeraraghavan (1990) in cashew and Kaur (2018) in sapota.

Height of grafted plant

The rootstock R_7 (Nekkere) (29.40 cm) and scion variety S_3 (Kesar) (26.74 cm) recorded the highest plant height. Among different rootstocks, R_7S_3 (Nekkere + Kesar) registered the maximum height of grafted plant (33.55 cm). The height of the grafted plant is highly determined by growth parameters like leaf number and leaf area which helped in better production and synthesis of food material. The higher the leaf number more will be the photosynthetic rate which in turn helps in better growth of graft. Similar results were documented by Bobade et al. (2018) and Bose et al. (2019) in mango.

Scion girth

Among different rootstocks, the maximum scion girth was registered with R_9 (Bappakai) (5.67 mm). This better increase in scion girth might be due to the compatibility of the rootstock and scion with enhanced vigorous vascular cambium activity resulting in rapid graft union combined with conducive climatic conditions and higher leaf number which synthesize more food both in stock and scion. Similar results were documented by Bharatbhai et al. (2013) and Sukhjit Kaur et al. (2017) in mango. Scion girth was found non-significant for different scion varieties and the interaction effect between rootstock and scion.

Root collar diameter

Among different rootstocks, scion varieties and interaction effects on root collar diameter not influenced. However, the maximum root collar diameter was recorded with rootstock R_9 (Bappakai) (6.57 mm), scion variety (Kesar) (6.51 mm) and among interaction effects, the maximum root collar diameter was recorded with R_7S_3 and R_9S_1 (5.75 mm) at 30 DAG and R_9S_3 (6.32 mm) at 60 DAG and R_9S_2 (6.71 mm) at 90 DAG and the minimum was recorded with $R_{11}S_2$ (5.34, 5.89 and 5.97

mm) at 30, 60 and 90 DAG. This might be due to differential reduced variations in the growth of scion and rootstocks. Similar results were documented by Minja et al. (2017).

Number of leaves per graft

The rootstock R_7 (Nekkere) and scion variety S_3 (Kesar) (16.88/ graft) registered the highest number of leaves (18.33 /graft). In the case of interactions, the maximum number of leaves per graft (16.20/graft) was registered with R_7S_3 (Nekkere + Kesar). This increase in the number of leaves might be due to the vigorous growth of seedlings and high photosynthates accumulation in newly grafted plants which in turn helps in increased absorption of nutrients and production of a greater number of leaves on the grafted plant. Similar results were documented by Jana (2007) and Ram et al. (2012) in mango.

Table 1. Effect of different mango rootstocks and scion combinations on days for sprout emergence, sprout length and graft success

Treatment	Days for emergence of sprouts				Sprout length 45 DAG				Graft success 45 DAG			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
R_1	17.00^{c}	17.60^{c}	16.50^{c}	17.03^{f}	5.18^{d}	4.40^{e}	4.80^{e}	4.79^{f}	82.50	82.50	90.00	85.55^{b}
R_2	17.70^{c}	18.10^{b}	18.40^{b}	18.07^{d}	4.71^{e}	4.34^{e}	5.04^{d}	4.70^{g}	70.00	70.00	90.00	76.67^{d}
R_3	17.10^{c}	16.40^{c}	15.60^{d}	16.37^{g}	5.11^{d}	4.96^{d}	5.35^{d}	5.14^{d}	85.00	72.50	85.00	80.83^{c}
R_4	18.00^{b}	18.00^{b}	16.90^{c}	17.63^{e}	4.67^{e}	4.87^{d}	5.59^{c}	5.04^{e}	70.00	75.00	92.50	79.17^{d}
R_5	18.50^{b}	21.30^{a}	19.00^{b}	19.60^{b}	4.62^{e}	4.67^{e}	4.30^{e}	4.59^{g}	67.50	65.00	75.00	69.17^{e}
R_6	18.80^{b}	18.60^{b}	19.10^{b}	18.83^{c}	4.74^{e}	4.60^{e}	5.10^{d}	4.81^{f}	67.50	60.00	72.50	66.67^{e}
R_7	12.70^{e}	13.30^{e}	11.40^{f}	12.47^{g}	5.37^{d}	5.73^{c}	7.15^{a}	6.08^{a}	85.00	67.50	95.00	89.17^{a}
R_8	16.00^{c}	14.20^{d}	14.90^{d}	15.03^{g}	5.21^{d}	5.45^{d}	5.58^{c}	5.41^{c}	80.00	77.50	92.50	83.33^{b}
R_9	13.30^{e}	12.30^{f}	11.90^{f}	12.50^{g}	5.33^{d}	5.50^{c}	6.21^{b}	5.68^{b}	85.00	80.00	95.00	86.67^{a}
R_{10}	13.00^{e}	14.30^{d}	12.30^{f}	13.20^{h}	4.95^{d}	5.00^{d}	5.84^{c}	5.26^{d}	70.00	70.00	90.00	76.67^{d}
R_{11}	19.00^{b}	21.30^{a}	20.40^{a}	20.23^{a}	4.43^{e}	2.95^{g}	3.70^{f}	3.69^{h}	55.00	55.00	65.00	58.33^{f}
R_{12}	17.40^{c}	18.00^{b}	14.60^{d}	16.67^{f}	4.75^{e}	5.14^{d}	5.98^{c}	5.29^{d}	82.50	77.50	87.50	82.50^{c}
Mean	16.54^{a}	16.96^{a}	15.92^{b}		4.92^{b}	4.80^{b}	5.39^{a}		75.00^{b}	72.71^{c}	85.83^{a}	
Comparison	**S.Em±**		**CD (0.05)**		**S.Em ±**		**CD (0.05)**		**S.Em ±**		**CD (0.05)**	
R	0.18		0.51		0.07		0.19		1.14		3.26	
S	0.36		1.03		0.13		0.38		2.27		6.52	
R×S	0.62		1.78		0.23		0.65		3.94		NS	
CV (%)	5.32				6.37				7.15			

R= Rootstocks **S**= Scions

R_1- Kurukkan **R_3**- Olour **R_5**-Kensington **R_7**- Nekkere **R_9**-Bappakai **R_{11}**-Starch **S_1**- Baneshan **S_3**- Kesar

R_2- Kitchner **R_4**- EC-95862 **R_6**- Peach **R_8**- Muvandan **R_{10}**-Mylepelian **R_{12}**-Local **S_2**- Dashehari **DAG-** Days after Grafting

Table 2. Effect of different mango rootstocks and scion combinations on height of grafted plant, scion girth and root collar diameter

Treatment	Height of grafted plant 45 DAG				Scion girth (mm) 90 DAG				Root collar diameter (mm) 90 DAG			
	S_1	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**
R_1	26.44^{c}	25.41^{c}	26.82^{c}	26.22^{d}	5.65	5.56	5.49	5.57^{b}	6.45	6.42	6.62	6.50
R_2	25.21^{c}	25.95^{c}	26.70^{c}	25.95^{e}	5.55	5.60	5.47	5.54^{b}	6.44	6.46	6.50	6.46
R_3	26.79^{c}	27.15^{c}	28.41^{b}	27.45c	5.62	5.42	5.56	5.53^{b}	6.46	6.43	6.59	6.49
R_4	27.34^{c}	25.90^{c}	27.24^{c}	26.82d	5.63	5.46	5.56	5.55^{b}	6.47	6.49	6.57	6.51
R_5	25.55^{c}	24.97^{c}	26.31^{c}	25.61^{e}	5.48	5.60	5.54	5.54^{b}	6.46	6.47	6.43	6.45
R_6	21.50^{e}	21.42^{e}	22.70^{d}	21.87^{g}	5.56	5.53	5.44	5.51^{c}	6.37	6.41	6.45	6.41
R_7	26.93^{c}	27.72^{c}	33.55^{a}	29.40^{a}	5.44	5.63	5.69	5.59^{b}	6.53	6.42	6.45	6.47
R_8	27.15^{c}	24.65^{d}	25.71^{c}	25.84^{e}	5.59	5.51	5.60	5.57^{b}	6.39	6.54	6.52	6.48
R_9	27.04^{c}	28.47^{b}	29.24^{b}	28.25^{b}	5.63	5.60	5.78	5.67^{a}	6.37	6.71	6.63	6.57
R_{10}	25.20^{c}	23.08^{d}	28.40^{b}	25.56^{e}	5.48	5.48	5.54	5.50^{c}	6.40	6.52	6.42	6.45
R_{11}	21.10^{e}	16.50^{f}	21.40^{e}	19.67^{h}	5.39	5.31	5.33	5.34^{d}	6.52	5.97	6.44	6.31
R_{12}	24.65^{d}	24.75^{d}	24.42^{d}	24.61^{h}	5.49	5.50	5.58	5.52^{c}	6.48	6.37	6.52	6.46
Mean	25.41^{a}	24.66^{b}	26.74^{a}		5.54	5.52	5.55		6.44	6.43	6.51	
Comparison	**S.Em ±**		**CD (0.05)**		**S.Em ±**		**CD (0.05)**		**S.Em ±**		**CD (0.05)**	
R	0.29		0.84		0.03		0.07		0.04		NS	
S	0.58		1.67		0.05		NS		0.07		NS	
R×S	1.01		2.90		0.09		NS		0.13		NS	
CV (%)	5.58				2.20				2.73			

R= Rootstocks **S**= Scions

R_1- Kurukkan **R_3**- Olour **R_5**-Kensington **R_7**- Nekkere **R_9**-Bappakai **R_{11}**-Starch **S_1**- Baneshan **S_3**- Kesar

R_2- Kitchner **R_4**- EC-95862 **R_6**- Peach **R_8**- Muvandan **R_{10}**-Mylepelian **R_{12}**-Local **S_2**- Dashehari **DAG-** Days after Grafting

Table 3. Effect of different mango rootstocks and scion combinations on number of leaves per graft

Scion varieties	Number of leaves per graft (90 DAG)			
Rootstocks	**S_1**	**S_2**	**S_3**	**Mean**
R_1	16.30	15.20	16.80	16.20^{f}
R_2	15.20	15.00	15.50	15.23^{g}
R_3	17.00	17.10	17.60	17.23^{e}
R_4	18.00	17.50	18.00	17.83^{b}
R_5	14.30	14.20	15.80	14.77^{h}
R_6	12.90	12.40	13.30	12.87^{i}
R_7	17.90	17.40	19.70	18.33^{a}
R_8	17.20	16.80	18.00	17.33^{d}
R_9	17.60	17.10	18.40	17.70^{c}
R_{10}	17.90	17.20	18.50	17.87^{b}
R_{11}	12.40	11.90	13.10	12.47^{j}
R_{12}	17.10	16.40	17.90	17.13^{e}
Mean	16.15^{b}	15.71^{c}	16.88^{a}	
Comparison	S.Em ±		CD (0.05)	
R	0.10		0.28	
S	0.19		0.56	
R×S	0.34		NS	
CV (%)	2.92			

R= Rootstocks **S**= Scions **DAG-** Days after Grafting
R_1- Kurukkan **R_3**- Olour **R_5**-Kensington **R_7**- Nekkere
R_9-Bappakai **R_{11}**-Starch **S_1**- Baneshan **S_3**- Kesar
R_2- Kitchner **R_4**- EC-95862 **R_6**- Peach **R_8**- Muvandan
R_{10}-Mylepelian **R_{12}**-Local **S_2**- Dashehari

CONCLUSION

From the present investigation, it can be concluded that the rootstocks named Olour, Kitchner, Bappakai and Nekkere performed best with respect to germination percentage, days taken for 50 per cent germination, root length and seedling height. Polyembryonic rootstocks Nekkere, Bappakai, Muvandan, EC-95862 and Mylepelian showed higher seedling vigour whereas, Starch, Peach and Kitchner showed less seedling vigour. Extent of polyembryony was registered highest with Kurukkan and Peach. Among different scion varieties, Kesar outperformed Dashehari and Baneshan. In case of rootstock-scion combinations Nekkere grafted with Kesar was the best treatment with respect to number of days taken for emergence of sprout, sprout length, graft success, height of grafted plant, scion girth, root collar diameter and number of leaves per graft.

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Research Article

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Genetic variability in heat tolerant maize (*Zea mays* L.) hybrids and their parents for yield and grain quality traits

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ABSTRACT
The present investigation was carried out to estimate genetic variability, heritability and GAM in inbred lines and hybrids. ANOVA indicated the availability of considerable variation for all the characters among inbred lines and hybrids except for ASI. PCV was higher than the GCV for all the characters. In inbred lines, important traits like plant height, number of grains per row, number of grains per cob, 1000-grain weight, grain yield per plant, dietary fibre, and β-carotene exhibited high PCV and GCV along with high heritability and GAM. Whereas, hybrids showed high values of PCV and GCV for ASI, phytic acid and high heritability coupled with high GAM were observed for traits like ASI, plant height, number of grains per row, number of grains per cob, shelling percentage, grain yield per plant, protein, dietary fibre, and β-carotene indicating the presence of variability in inbred lines and hybrids for these traits. Hence, simple selection for these traits in early generations for developing heat-tolerant maize lines can be practised.
Keywords: Heat tolerance, GCV, PCV, heritability and GAM.

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal and staple food crop of the world. Maize is an important source of carbohydrates, protein, vitamins and minerals for humans and animals. The rapidly increasing human population is an alarming issue and would need more food production under changing climate. Abiotic stresses like heat stress and temperature fluctuation are becoming key issues to be addressed for boosting crop production. Grain yield losses in maize from heat stress are expected to increase owing to a higher temperature during the growing season. This situation demands the development of maize hybrids tolerant to heat stress without compromising grain yield and quality under stress conditions (Sabagh *et al*., 2020). Under the Heat Stress Tolerant Maize for Asia (HTMA) project, UAS, Raichur in collaboration with CIMMYT has identified several heat stress tolerant maize hybrids and released a heat tolerant hybrid, RCRMH 2 for cultivation in Karnataka, recently. Department of Biotechnology, UAS, Bangalore in collaboration with UAS, Raichur has also identified a few heat stress tolerant maize inbred lines. Therefore, there is a need to evaluate all these inbred lines and hybrids for grain yield and quality traits and to identify the superior inbred lines and hybrids for grain yield and quality traits and their specific utilization.

Genetic variability is a pre-requisite and important tool of any breeding programme. It provides not only the basis of selection but also some valuable information regarding the selection of diverse parents for use in the hybridization programme. Heritability is the most important among the parameters as this will provide information on whether the trait is genetically inherited or influenced by the environment and how this can be improved. Burton (1952) suggested that the genetic components of variation together with heritability estimates would give the best picture of the amount of genetic advance to be expected from the selection. Many reports on estimates of genetic variability are available in maize information on released genotypes is limited. Hence the present study was planned to determine the estimates of variability, heritability and genetic advance as a per cent of the mean for yield and grain quality traits.

MATERIALS AND METHODS

The experiment was carried out during *Kharif* 2019 at Main Agricultural Research Station, Raichur. Experimental material for the present investigation comprised 14 hybrids and three commercial checks and 21 inbred lines and two testers which were obtained from the College of Agriculture, Bheemarayanagudi. The inbred lines used in this study are parental lines of hybrids allocated to UAS, Raichur by CIMMYT. Two separate experiments were laid out in RBD with two replications. Each entry was grown in two rows of 4.0 m in length at a spacing of 60 cm between rows and 20 cm within rows. From each row two plants which are of equal height were selected for manual selfing to develop pure parental seed for assessing quality traits. The selfing process includes bagging of silk, tassel and hand pollination.

The data on morphological traits like Days to 50 % anthesis, Days to 50 % silking, Anthesis to Silking Interval (ASI), Plant height (cm), Ear height (cm), Number of grains per row, Number of grains per cob, Shelling percentage, 1000-grain weight (g) and Grain yield kg/ha were recorded on five randomly selected plants per entry per replication except days to 50 % tasselling and days to 50 % silking which were recorded on plot basis and quality traits like Protein (%), Carbohydrate (%), Dietary fibre (g), β-carotene (mg), Phytic acid (mg) were estimated from seeds obtained from self-pollinated plants and characters were analyzed to estimate genetic variability parameters. Genetic variability was measured and subjected to statistical analysis as suggested by Robinson *et al.* (1949). Heritability (broad sense) and Genetic Advance as a per cent of Mean (GAM) were worked by following the method suggested by Robinson *et al*. (1949) and Johnson *et al.* (1955), respectively.

RESULTS AND DISCUSSION

In the present investigation, analysis of variance indicated that the mean sum of square due to inbred lines and hybrids exhibited significant variation among inbred lines and hybrids for all the characters except ASI indicating the existence of a high level of variability for these traits among inbred lines and hybrids and the possibility of selection of traits of interest. The results of the analysis of variance for 15 characters in maize inbred lines and hybrids are presented in Table 1 and Table 2, respectively.

The mean performance, range, variability, heritability and GAM for yield, yield attributing and grain quality traits across inbred lines and hybrids are presented in Table 3 and Table 4, respectively. It is evident from both tables that the magnitude of PCV was higher than that of the GCV for yield, yield attributing and grain quality traits indicating the larger influence of environment for the expression of these characters which is similar to the study made by Sharma *et al*. (2014). In inbred lines, the values for PCV obtained for different characters ranged from 3.10 % for carbohydrates to 45.90 % for β-carotene and the values for GCV ranged from 2.87 % for carbohydrates to 40.16 % for β-carotene. The PCV and GCV values were high for ASI, plant height, ear height, number of grains per row, number of grains per cob, 1000-grain weight, grain yield per plant, dietary fibre, β-carotene and phytic acid. It indicates the presence of a considerable level of observable variation among the inbred lines for a trait and suggests that the selection based on this trait would facilitate the successful isolation of desirable types with high grain yield. Similar results were observed by Gazala *et al.* (2017). Low PCV and GCV were recorded for days to 50 % anthesis, days to 50 % silking, shelling percentage, protein and carbohydrate indicating the presence of less variability among inbred lines for these traits. Similar results were observed by Sharma *et al*. (2016).

In hybrids, the values for PCV obtained for different characters ranged from 3.58 % for carbohydrates to 26.72 % for ASI and the values for GCV ranged from 3.26 % for carbohydrates to 22.54 % for phytic acid. The PCV and GCV values were high for ASI and phytic acid. Low PCV and GCV were observed for traits like days to 50% anthesis, days to 50% silking, ear height, shelling percentage and carbohydrate. This indicates that there is a need to create variability for these traits among hybrids. Similar results were observed by Prakash *et al*. (2016) and Ogunniyan and Olakojo (2014).

In inbred lines, estimates of heritability ranged from 50.1 % for days to 50 % anthesis to 98.6 % for plant height and estimates of GAM ranged from 5.48 % for carbohydrate to 77.86 % for grain yield per plant. High heritability along with high GAM was observed for traits like ASI, plant height, ear height, number of grains per row, number of grains per cob, 1000-grain weight, grain yield per plant, dietary fibre and β-carotene which indicated that these traits were governed by additive gene action and least influenced by environmental factors and more valuable in predicting the effect of selection. Similar kind of observations was made by Bharathiveeramani *et al.* (2012) and Sandeep *et al.* (2013). High heritability and moderate GAM were observed for protein while, high heritability and low GAM were observed for days to 50 % silking, shelling percentage and carbohydrate indicating the involvement of non-additive gene action in the expression of the trait. The high heritability exhibited was due to the favourable influence of environment rather than genotypes and further suggesting the importance of dominance and epistatic effects in the inheritance of the trait and selection would be less effective. Low heritability and high GAM were observed for phytic acid. Low heritability and low GAM were observed for days to 50 % anthesis.

In hybrids estimates of heritability ranged from 33.2 % for phytic acid to 98.4 % for dietary fibre and estimates of GAM ranged from 5.97 % for 1000-grain weight to 33.94 % for several grains per row. High heritability coupled with high GAM was observed for traits like ASI, plant height, number of grains per row, number of grains

per cob, shelling percentage, grain yield per plant, protein, dietary fibre and β-carotene indicating that the genetic variance for these traits is probably owing to their high additive gene effects and thus there is a better scope for improvement of these traits through direct selection. Similar results were observed by Sumathi *et al.* (2005) and Nataraj *et al*. (2014).

Table 1. Analysis of variance for yield, yield attributing and grain quality traits in maize inbred lines.

Source of variation	Df	Days to 50% anthesis	Days to 50% silking	Anthesis to silking interval	Plant height	Ear height	Number of grains per row	Number of grains per cob	Shelling percent	1000-grain weight	Grain yield per plant
Replication	1	2.63	4.26	0.08	157.06	38.34	11.50	13982.70	27.70	6528.34	9.86
Treatment	22	30.74**	22.96**	2.40	2372.75**	621.12**	154.33**	37755.01**	33.88**	8194.52**	639.76**
Error	22	10.22	5.71	0.99	16.97	21.48	5.04	3768.55	3.77	938.25	23.86

** Significant at 1% level (P = 0.01)

Table 1. Contd….

Source of variation	Df	Protein	Carbohydrate	Dietary fiber	β-Carotene	Phytic acid
Replication	1	1.43	4.86	0.06	0.04	0.12
Treatment	22	1.38**	7.63**	1.62**	1.11**	5.09**
Error	22	0.33	0.59	0.07	0.14	1.16

** Significant at 1% level (P = 0.01)

Table 2. Analysis of variance for yield, yield attributing and grain quality traits in maize hybrids

Source of variation	Df	Days to 50% anthesis	Days to 50% silking	Anthesis to silking interval	Plant height	Ear height	Number of grains per row	Number of grains per cob	Shelling percent	1000-grain weight	Grain yield per plant
Replication	1	0.03	0.47	0.11	0.47	24.73	10.61	1972.97	0.015	2863.05	19.88
Treatment	16	22.55**	20.94**	0.99	1034.37**	153.52**	93.86**	17388.31**	19.07**	5581.99**	595.68**
Error	16	3.37	3.78	0.24	37.53	8.86	8.11	3425.09	3.46	743.12	14.81

** Significant at 1% level (P = 0.01)

Table 2. Contd….

Source of variation	Df	Protein	Carbohydrate	Dietary fiber	β-Carotene	Phytic acid
Replication	1	0.0049	4.44	0.001	0.001	0.188
Treatment	16	3.001**	10.83**	1.285**	0.462**	7.179**
Error	16	0.260	1.02	0.010	0.082	0.658

** Significant at 1% level (P = 0.01)

Table 3. Genetic variability parameters for yield, yield attributing and grain quality traits in maize (*Zea mays* L.) inbred lines.

Sl. No.	Character	Mean ± SE	Range		Coefficient of variation		h^2 (%) (Broad sense)	GAM (5%)
			Minimum	Maximum	PCV (%)	GCV (%)		
1	Days to 50% anthesis	57.15 ± 2.26	48.50	63.50	7.91	5.60	50.1	8.17
2	Days to 50% silking	59.87 ± 1.69	52.50	65.50	6.32	4.90	60.1	7.83
3	Anthesis to silking interval	3.26 ± 0.70	1.50	6.00	39.98	25.72	62.4	34.09
4	Plant height (cm)	168.41 ± 2.91	108.00	245.50	20.52	20.37	98.6	41.68
5	Ear height (cm)	80.30 ± 3.27	54.50	106.00	22.32	21.56	93.3	42.90
6	Number of grains per row	25.15 ± 1.58	10.00	38.00	35.49	34.35	93.7	68.48
7	Number of grains per cob	336.56± 43.40	105.00	580.50	42.81	38.73	81.8	72.18
8	Shelling percentage	78.10 ± 1.37	71.95	84.93	5.55	4.96	80	9.15
9	1000-grain weight (g)	289.47 ±21.65	185.00	411.00	23.34	20.80	79.5	38.20
10	Grain yield per plant(g)	44.72 ± 3.45	21.25	76.25	40.72	39.23	92.8	77.86
11	Protein (%)	9.53 ± 0.41	7.94	11.35	9.75	7.60	60.7	12.20
12	Carbohydrates (%)	65.25 ± 0.54	61.79	69.38	3.10	2.87	85.6	5.48
13	Dietary fiber (g/100g)	4.06 ± 0.19	2.07	5.30	22.71	21.65	90.9	42.52
14	β-carotene (mg/100g)	1.73 ± 0.27	0.29	3.00	45.90	40.16	76.5	72.38
15	Phytic acid(mg/100g)	5.08 ± 0.76	1.93	8.89	34.77	27.52	52.7	44.88

Table 4. Genetic variability parameters for yield, yield attributing and grain quality traits in maize (*Zea mays* L.) hybrids.

Sl. No.	Character	Mean ± SE	Range		Coefficient of variation		h^2 (%) (Broad sense)	GAM (5%)
			Minimum	Maximum	PCV (%)	GCV (%)		
1	Days to 50% anthesis	50.82 ± 1.29	43.00	56.00	7.08	6.09	74.1	10.79
2	Days to 50% silking	53.76 ± 1.37	47.00	59.50	6.54	5.44	69.4	9.35
3	Anthesis to silking interval	2.94 ± 0.34	2.00	4.00	26.72	20.82	60.7	33.42
4	Plant height (cm)	206.17 ± 4.33	153.00	215.00	11.22	10.82	93	21.51
5	Ear height (cm)	96.97 ± 2.10	83.00	115.00	9.29	8.77	89.1	17.05
6	Number of grains per row	36.44 ± 2.01	26.50	46.00	19.59	17.96	84.1	33.94
7	Number of grains per cob	595.20 ± 41.38	340.50	731.00	17.13	14.03	67.1	23.06
8	Shelling percentage	80.23 ± 1.31	75.18	86.90	4.18	3.48	69.3	25.82
9	1000-grain weight (g)	343.17 ± 19.27	256.00	420.00	16.38	14.33	76.5	5.97
10	Grain yield per plant(g)	153.0 ± 2.72	121.50	185.00	11.41	11.13	95.1	22.38
11	Protein (%)	9.49 ± 0.36	7.75	11.65	13.45	12.33	84	23.29
12	Carbohydrates (%)	67.95 ± 0.71	62.42	71.60	3.58	3.26	82.7	6.10
13	Dietary fiber (g/100g)	6.25 ± 0.07	4.80	7.70	12.87	12.77	98.4	26.10
14	β-carotene (mg/100g)	2.55 ± 0.20	1.77	3.46	20.41	17.06	69.8	29.37
15	Phytic acid(mg/100g)	8.01 ± 0.57	4.75	11.19	24.71	22.54	33.2	12.35

High heritability coupled with moderate GAM was observed for traits like days to 50 % anthesis and ear height indicating that the improvement of these traits is possible only through direct and restricted selection. High heritability with low GAM was observed for traits like days to 50 % silking, 1000-grain weight and carbohydrate content. This indicates that the predominance of non-additive gene action and hence an improvement of such trait is complicated. Similar results were observed by Lal and Singh (2014). Moderate heritability with moderate GAM was observed for traits like phytic acid which indicates that intermediate expression of both additive and dominant gene effects.

CONCLUSION

It can be concluded that in inbred lines important traits like plant height, number of grains per row, number of grains per cob, 1000-grain weight, grain yield per plant, dietary fibre and β-carotene exhibited high PCV and GCV along with high heritability and GAM and in hybrids, PCV and GCV values were high for ASI, phytic acid and high heritability coupled with high GAM were observed for traits like ASI, plant height, number of grains per row, number of grains per cob, shelling percentage, grain yield per plant, protein, dietary fibre and β-carotene. This shows the presence of considerable variation among the inbred lines and hybrids for these traits and the possibilities of improvement of these traits through selection.

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Research Article

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Osmotic dehydration influence on marking nut (*Semecarpus anacardium*)

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ABSTRACT
Marking nut (*Semecarpus anacardium*) is one of the underutilized minor crops growing wildly in our country. This fruit has got great medicinal properties and health benefits. But its importance is not completely understood and the fruits go waste. Therefore, it is necessary to develop value-added products and osmotically dehydrated fruits have good potential. The inclusion of an osmotic process in conventional dehydration has two major advantages quality improvement and energy savings. There was a significant difference found in the samples prepared from different pretreatments of osmotic dehydration. Osmotic pretreatment T3 (Sucrose 60º Brix. + 18 hrs of immersion + Drying at 60º C) had a great influence on the quality and organoleptic properties of the fruits with maximum solid gain (86.40 %), carbohydrates (75.78 %) and minimum scores for moisture (13.60 %). Also, the highest scores for organoleptic parameters like colour (4), appearance (4), texture (3.75) and taste (3.75) were recorded in the same sample.
Keywords: Heat tolerance, GCV, PCV, heritability and GAM.

INTRODUCTION

Marking nut (*Semecarpus anacardium*) commonly known as phobi nut tree and varnish tree is an under-exploited minor fruit native to India, found in the outer Himalayas to the Coromandel Coast and wildly grown in the North Eastern Transition Zone of Karnataka. It is a member of Anacardiaceae family and is closely related to the cashew. It is a deciduous tree. The flowers are greenish white, in panicles and appear with new leaves in May and June, easily recognized by large leaves and the red blaze exuding resin, which blackens on exposure. The nut is about 2.5 cm long, ovoid and smooth lustrous black (Semalty *et al.*, 2010). The fruit is composed of two parts, a reddish-orange accessory fruit and a black drupe that grows at the end. The accessory fruit is edible and sweet when ripe. It is also known as *kerbeeja* in Kannada. It is well known for its nutritional and medicinal values. Various parts of these plants are commonly used in the Ayurvedic system of medicine for the treatment of various ailments, mainly alimentary tract and certain dermatological conditions. Reports have shown a noticeable impact on illnesses related to the heart, blood pressure, respiration, cancer and neurological disorders (Patel *et al*., 2009).

The application of the osmotic dehydration process in the production of a safe, stable, nutritious, tasty and economical product is gaining more attention. This process involves placing solid food, whole or in pieces in a sugar or salt aqueous solution of high osmotic pressure which removes 30–50 % of the water from fresh ripe fruits such as mango, pineapple, sapota, papaya, guava and jackfruit (Lewicki and Lenart 1995). The quality of dried fruits is enhanced to a great extent due to an increase in sugar content, reduction of sour taste and prevention of loss of natural flavour along with better retention of nutrients. The major advantage of the inclusion of an osmotic process in conventional dehydration is quality improvement (Pointing *et al*. 1966; Raoult-wack 1994) and energy savings (Raoult-wack 1994 and Lewicki and Lenart 1995). The influence of osmotic agents on drying behaviour and product quality has been reviewed by several workers (Lerici *et al*. 1985; Rastogi *et al*., 2002 Tiwari 2005). Osmotic dehydration in fruits such as banana (Pokharkar *et al*. 1997; Thippanna and Tiwari 2015), papaya (Ahemed and Choudhary 1995), mango (Nanjundaswami *et al*. 1978 and Madamba and Lopez 2002) and pineapple (Beristian *et al*. 1990 and Rahman and Lamb 1990) has been attempted. The present investigation was carried out to study the effect of osmotic dehydration to enhance the postharvest life of marking nut fruit and to study the effect of osmotic dehydration on the sensory quality of marking nut.

MATERIALS AND METHODS

The experiment was conducted in the College of Horticulture, Bidar 2017-18. The fresh fruits were harvested and washed. The marking nut apples were separated from the fruits. They were soaked in different solutions according to the set treatments and subjected to dehydration using a tray drier. The proximate composition of the fruits was analyzed (Table 1).

Table 1. Nutrient composition of marking nut apple (%)

Moisture	53.52
Ash	1.56
Protein	3.51
Fibre	5.58
Fat	0.15
Carbohydrate	35.65

Treatments

The fruits were dipped in 40, 50 and 60° Brix sugar syrup containing 0.2 % of citric acid and 0.1 % each of potassium metabisulphite (KMS) in a 1:2 fruit-to syrup ratio and allowed to undergo osmosis for 18 hrs at room temperature (25–35 °C) for T1, T2 and T3 respectively. Slices were drained and rinsed with water to remove adhering syrup. For T4 and T5, the fruits were directly dried at 60º C and in sunlight respectively without pretreatment.

T1- Sucrose 40º Brix.+ 18 hrs of immersion +Drying at 60º C
T2- Sucrose 50º Brix.+ 18 hrs of immersion + Drying at 60º C
T3- Sucrose 60º Brix.+ 18 hrs of immersion + Drying at 60º C
T4- Drying at 60º C
T5- Sun drying

Marking nut apples are separated from the fruit sugar syrups are prepared as per the treatments

Dehydration

Osmosed slices from different treatments were spread on stainless steel trays and were dehydrated in a cabinet drier at 60° C on to a constant moisture level (except T5). The dried samples were packed in polythene covers.

Physico-chemical analysis

The dried samples were analysed for different attributes. Moisture content was determined by drying the samples to a constant weight in a hot air oven at 70±1 °C and using the following formula. The total solids were calculated by subtracting the moisture content from 100.

Moisture content =Initial weight – Dried weightX100

Soaking in the sugar syrup solution for 18 hrs Dehydrating in an electric drier

Fig. 1. Different operations in osmotic dehydration treatment

Dried weight

The biochemical analysis of parameters like carbohydrates, proteins, fats, fiber and ash was done using the AOAC standard procedures (Edition 2016).

Sensory analysis

The osmotically dehydrated samples were evaluated by a sensory panel using a hedonic scale having scores ranging from very good (5) to very poor (1) for the attributes like color, appearance, texture and taste.

Statistical analysis

The experiment was carried out by using a Completely Randomized Design (CRD) with 5 treatments and 3 replications. The data for variations in different Physico-chemical attributes were analyzed by using the Analysis of variance (ANOVA) technique.

Fig. 2. Treated marking nut samples

RESULTS AND DISCUSSION

Physico-chemical parameters of osmotically dehydrated fruits:

The data about the moisture content and total solids in different treatments are presented in Table 2. The moisture content varied in different treatments with a minimum (13.60 %) in T3 (Sucrose 60º Brix. + 18 hrs of immersion + Drying at 60º C) followed by T2 (Sucrose 50º Brix. + 18 hrs of immersion + Drying at 60º C) to maximum (23.91 %) in T4 (Drying at 60º C). The content of total solids reciprocated the result of moisture content as the maximum total solids content (86.4 %) was observed in T3 (Sucrose 60º Brix. + 18 hrs of immersion + Drying at 60º C) followed by T2 (Sucrose 50º Brix. + 18 hrs of immersion + Drying at 60º C) whereas the minimum (76.09 %) was found in T4 (Drying at 60º C). The fruits immersed in osmotic solutions gain equilibrium in the solution by losing the moisture content and gaining the solids from the solution.

Osmotic treatment with sucrose syrup lowered the drip loss and moisture content of frozen pineapples (Khan, 2012). Yan *et al.* (2008) pointed out that the specific volume, shrinkage and porosity of bananas, pineapple and mango decreased as moisture content decreased during drying. Studies made by several workers indicate that increasing the sugar syrup concentration favors water loss and also resulted in solid gain (Pointing *et al*. 1966; Hawkes and Flink 1978 and Torreggiani 1993).

Table 2. Effect of osmotic dehydration on moisture content and total solids of marking apple

Treatments	Moisture Content (%)	Total solids (%)
T1-40% Sucrose	16.82	83.18
T2-50% Sucrose	14.20	85.80
T3-60% Sucrose	13.60	86.40
T4-Drying at 60°C	23.91	76.09
T5-Sun drying	18.79	81.21
C.D.@ 0.1%	0.81	0.81
SE(m)±	0.25	0.25

The data pertaining to carbohydrates, proteins, fat, fiber and ash content in different treatments are presented in Table 3. The maximum value (75.78 %) for carbohydrates was observed in T3 (Sucrose 60º Brix. + 18 hrs of immersion + Drying at 60º C) followed by T2 (Sucrose 50º Brix. + 18 hrs of immersion + Drying at 60º C) and the minimum (61.15 %) was found in T4 (Drying at 60º C). The increased carbohydrate content reflected the sugar absorbed by the samples. These results indicate that syrup concentration had a significant effect on the composition of osmotically dehydrated samples. This increase in sugar content in fruits during the osmotic dehydration process has been reported (Torreggiani1993; Raoult-Wack *et al*. 1991 Sankat *et al*. 1996). Giraldo *et al*. (2003) stated that variables affecting osmotic dehydration kinetics also affect sugar content in the final products. The results of the present study conform with the observations made by several earlier workers (Sagar and Khurdiya 1999 and Sharma *et al*. 2004). The protein, fat and ash content were maximum (5.35 %, 1.28 % and 4.18 % respectively) in T5 (Sun drying) and minimum (3.50 %, 0.88 % and 2.72 % respectively) in T1 (Sucrose 40º Brix. + 18 hrs of immersion + Drying at 60º C). The maximum fibre content (6.54 %) was found in T2 (Sucrose 50º Brix. + 18 hrs of immersion + Drying at 60º C) and the minimum (2.89 %) was recorded in T3 (Sucrose 60º Brix. + 18 hrs of immersion + Drying at 60º C). The chemical composition (fat, protein, salt and carbohydrate), and physical structure (fibre orientation, porosity and skin), may be affected by the kinetics of osmosis in food (Rahman and lamb 1990).

Table 3. Effect of osmotic dehydration on Physico-chemical parameters of marking apple

Treatments	Carbohydrates (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)
T1-40% sucrose	70.44	3.50	0.88	5.63	2.72
T2-50% sucrose	71.85	3.61	0.93	6.54	2.87
T3-60% sucrose	75.78	3.83	1.01	2.89	2.87
T4-Drying at 60°C	61.15	4.35	0.95	6.33	3.31
T5-Sun drying	66.62	5.35	1.28	3.59	4.18
C.D.@ 0.1%	0.68	0.07	0.06	0.17	0.07
SE(m)±	0.21	0.02	0.02	0.05	0.02

The sensory qualities of osmotically dehydrated marking nut apples are affected by different osmotic pre-treatments.

Color

The data about color is presented in Table 4. The highest score (4) was obtained by T3 (Sucrose 60º Brix. + 18 hrs of immersion + Drying at 60º C) and the lowest (2.5) was obtained by T4 (Drying at 60º C). Torreggiani (1993) reported that sugar uptake owing to the protective action of the sugars in syrup helps in the stability of product color during osmotic process and subsequent storage. Osmotic pretreatment and drying temperature had a significant effect on chroma and hue angle values of dried peppers (Falade and Oyedele 2010).

Appearance

The data regarding the appearance of the samples is depicted in Table 4. The maximum score (4) was obtained by T3 (Sucrose 60º Brix. + 18 hrs of immersion + Drying at 60º C) and the minimum (3) was for T4 (Drying at 60º C). Due to considerable solid gain by the slices, the loss in moisture was compensated and there was not much of deformity in the marking nut apples. These results conform with the findings on organoleptic properties of osmotically dehydrated bananas (Sankat *et al*. 1996). According to Varany-Anond *et al*. (2000), the best osmotic treatment for mango was 60°Brix sucrose at 50 °C for 4 hours.

Texture

The data about texture is presented in Table 4. The treatment T3 (Sucrose 60º Brix. + 18 hrs of immersion + Drying at 60º C) obtained the highest score (3.75) and treatment T5 (Sun drying) secured the lowest score (2.83) for texture. Improvement in the texture of osmotically dehydrated samples might be due to the positive role of sugars available in the fruit slices. The influence of osmotic agents on product quality has been reported by earlier workers in fruits such as papaya (Ahemed and Choudhary 1995), and mango (Sagar and Khurdiya 1999; Varany-Anond *et al*. 2000 and Madamba and Lopez 2002).

Taste

The data relating to taste is depicted in Table 4. The maximum score (3.75) was obtained byT3 (Sucrose 60º Brix. + 18 hrs of immersion + Drying at 60º C) and T5 (Sun drying). However, the minimum score (2.5) was obtained by T1 (Sucrose 40º Brix. + 18 hrs of immersion + Drying at 60º C). Improvement in the taste of osmotically treated slices from the above treatments was mainly due to a better sugar-acid ratio. It has been reported that variables affecting osmotic dehydration kinetics, as well as the final ratio of water loss and sugar gain has a great influence on product characteristics and improved product from fruits can be obtained through osmotic dehydration (Torreggiani1993; Raoult-Wack1994; Bongirwar 1997).

Table 4. Effect of osmotic treatment on organoleptic evaluation of marking apple

Treatments	Color (5)	Appearance (5)	Texture (5)	Taste (5)
T1-40% sucrose	3.50	3.75	3.50	2.50
T2-50% sucrose	3.50	3.42	3.50	3.00
T3-60% sucrose	4.00	4.00	3.75	3.75
T4-Drying at 60°C	2.50	3.00	3.00	3.58
T5-Sun drying	3.08	3.25	2.83	3.75
C.D.@ 0.1%	0.52	0.43	0.63	0.52
SE(m)±	0.16	0.13	0.20	0.16

CONCLUSION

Based on the physicochemical composition and sensory quality it was concluded that osmotic pretreatment of marking nut apples with 60°Brix sugar syrup with 18 hours of immersion and drying at 60º C was the best treatment. However, the sun-dried samples retained a higher amount of protein and fat content

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Research Article

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Response of rainfed Indian mustard to different tillage practices and mulching

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ABSTRACT
A field experiment was conducted during the *rabi* season of 2019 at College of Agriculture, Central Agricultural University, Imphal, Manipur. The experiment included the combination of two soil tillage systems viz., Conventional Tillage (L_1) and Minimum Tillage (L_2) and four different mulching materials viz., No mulch (M_1); Rice straw mulch (M_2); Polythene mulch (M_3) and Tree leave mulch (M_4). The Experiment was laid out in a split-plot design with different levels of tillage (main plot), and mulching materials (subplot) and each treatment were replicated thrice. The growth and yield of Indian mustard were influenced by different tillage practices and mulching. Maximum plant height (165.33 cm.), number of siliquae per plant (197) and seed yield (1790 kg/ha) and oil yield (692 kg/ha) were recorded in a combination of (L1M3) which received in Conventional tillage + Polythene mulch and minimum seed yield was recorded in a combination of (L2M1) 1441 kg/ha which received in Minimum tillage + No mulch. Maximum harvest index was recorded in a combination of (L1M2) 27.50% which was received in Conventional tillage +Rice straw mulch and minimum harvest index was recorded in a combination of (L1M4) 24.13% which was received in Conventional tillage + Tree leaves to mulch. The highest benefit-cost ratio (0.72) was recorded in Minimum tillage + Rice straw mulch because there was less input cost for tillage or ploughing activities and mulching material cost. The highest energy use efficiency, and energy productivity but lowest specific energy was observed in Minimum tillage with No mulch and energy use efficiency, and energy productivity but highest specific energy was observed in Minimum tillage with Rice straw mulch.
Keywords: Indian mustard, tillage, mulching, yield and energy.

INTRODUCTION

Among the edible *rabi* oilseeds of India, rapeseed-mustard is a major crop, being cultivated along with safflower, *rabi*- groundnut and *rabi*-sunflower. India holds a premier position in the rapeseed-mustard economy of the world with 2nd and 3rd rank in area and production, respectively. The relatively high content (36-38%) and quality of protein make the rapeseed-mustard seed meal valuable raw material for food as well as the feed industry. The good amino acid composition often compared to milk protein, contributes to high nutritive value (Kumar, 2012). Minimum tillage which has the potential to break the surface compact zone in soil with reduced soil disturbance offers to lead to a better soil environment and crop yield with minimal impact on the environment (Busari *et al.,* 2015). Conventional tillage is a tillage system used as the major means of seedbed preparation and weed control. It includes a sequence of soil tillage, such as ploughing and harrowing, to produce a fine seedbed, and also the removal of most of the plant residue from the previous crop.

The application of mulching practices reduces water evaporation, conserves soil moisture, suppresses weed growth, controls soil structure and temperature, influences soil micro-organisms, and is aesthetically pleasing. The effects of mulching materials on crop yield, productivity and water use efficiency. Plastic mulching materials have greater importance than organic ones to control the soil environment and increase crop yield. But organic mulching materials are inexpensive and environment friendly (Kader *et al.,* 2017).

Keeping in view of the above facts, the present investigation was undertaken during *rabi* 2019-2020 at Research Farm, College of Agriculture, Central Agricultural University, Imphal with the objective of conserving soil moisture as well as preventing weed growth in the Indian mustard field.

MATERIALS AND METHODS

A field experiment was undertaken during the *rabi* season of 2019 at College of Agriculture, Central Agricultural University, Imphal, Manipur. The experiment included the combination of two soil tillage

systems viz., Conventional Tillage (L_1) and Minimum Tillage (L_2) and four different mulching materials viz., No mulch (M_1); Rice straw mulch (M_2); Polythene mulch (M_3) and Tree leave mulch (M_4). The Experiment was laid out in a split-plot design with different levels of tillage (main plot), and mulching materials (subplot) and each treatment were replicated thrice. The soil of the experimental field was clay with pH (5.40), organic matter (2.07%), available nitrogen (291kg/ha), available P_2O_5 (16.78kg/ha) and available K_2O (212.3kg/ha) respectively. The average rainfall received during the crop growth period was 31.06 mm. The crop was sown on 15th December 2019 and harvested on 20th April 2020. The recommended dose of N:P: K was 80:40:40 kg/ha. The fertilizers were used in the form of urea, single super phosphate and muriate of potash. Full dose of phosphorous and potash along with half dose of urea were applied uniformly as a basal to all the plots three days before sowing. The remaining half dose of nitrogen was applied in two equal splits at 30 DAS and 60 DAS respectively.

Energy use efficiency described the total amount of energy used on a farm (in the form of electricity, diesel, or other sources) compared to the amount of production.

$$\text{Energy use efficiency} = \frac{\text{Energy output } (\frac{\text{GJ}}{\text{ha}})}{\text{Energy input } (\frac{\text{GJ}}{\text{ha}})}$$

Energy productivity was estimated by comparing the yield of mustard to the energy input

$$\text{Energy productivity (kg/MJ)} = \frac{\text{The yield of mustard } (\frac{\text{kg}}{\text{ha}})}{\text{Energy input } (\frac{\text{GJ}}{\text{ha}})}$$

Specific energy was estimated by comparing energy input to yield of mustard.

$$\text{Specific energy (MJ/kg)} = \frac{\text{Energy input } (\frac{\text{GJ}}{\text{ha}})}{\text{Yield of mustard } (\frac{\text{kg}}{\text{ha}})}$$

Statistical analysis of data

The data obtained from the experiment were subjected to statistical analysis by adopting the analysis of variance technique (Fisher, 1950) for "Split plot design". The significance of the difference among the treatment effect was tested through the 'F' test and critical difference (C.D.) at a 5% level of significance.

RESULTS AND DISCUSSION

Conventional tillage (L1) treated plots showed the highest plant height when compared to Minimum tillage (L2) plots. Plant height was recorded significantly higher in Conventional tillage (L1) practice (151.17 cm) compare to Minimum tillage (L2) practice (137.25 cm). This might be due to fine seedbed preparation in conventional tillage (L1) compared to Minimum tillage (L2) which leads to better root growth and deep root system development. This observation was supported by the work of Ved (2000), Kumar *et al*. (2016), and Mishra *et al.* (2019) in all these they had observed proper growth and development of plant was observed in conventional tillage plots.

The highest plant height was recorded under Polythene mulch (M3) followed by Rice straw mulch (M2) at all the stages of observation and the lowest plant height was recorded under No mulch (M1). This might be due to the better suppression of weed growth resulting in less competition and reduced loss of nutrients from the soil as compared to other treatments. The mulch help in weed suppression, increases soil fertility, maintains soil temperature and reduces leaching losses. This observation was supported by the work of Subrahmanyan *et al.* (2002), Yadav *et al.* (2006) Chinnathurai *et al.* (2012), Kader *et al.* (2017) and Anand *et al.* (2020).

Maximum plant height was recorded in a combination of (L1M3) which was received in Conventional tillage + Polythene mulch 165.33 cm. Minimum plant height was recorded in a combination of Minimum tillage + Rice straw mulch 131 cm. Mulching helps in the efficient utilization of resources like water, and nutrients, better suppression of weed growth, to maintain proper soil temperature and its properties which enhance the growth of beneficial microbes in soil cumulatively resulting in higher plant growth and yield development. This observation was supported by the work of Choudhary *et al.* (2017), and Mounika *et al.* (2020).

The number of primary branches per plant was recorded as significantly higher in Conventional tillage (5.29) as compared to Minimum tillage (4.08). This might be due to fine seedbed preparation in conventional tillage (L1) compared to Minimum tillage (L2) which leads to better crop growth and the development of mustard. This observation was supported by the work of Kumar *et al.* (2016), and Mishra *et al.* (2019) observed proper growth and development of plant was observed in conventional tillage plots.

The maximum mean number of primary branches per plant was found in Polythene mulch (4.91) whereas the minimum was found in no mulch (4.43 cm). This might be due to the better suppression of weed growth resulting in less competition and reduced loss of nutrients from the soil as compared to other treatments. The mulch help in weed suppression, increases soil fertility, maintains soil temperature and reduces leaching losses. This observation was supported by the work of Yadav (2006) and Anand *et al.* (2020).

Maximum primary branches per plant were recorded in a combination of Conventional tillage + Rice straw mulch (5.53). Minimum primary branches per plant were recorded in a combination of (L2M1) which received in Minimum tillage + Polythene mulch (3.53) at harvest. Maximum number of siliquae per plant was observed in conventional tillage (L1) 185 and the minimum number of siliquae per plant was observed in minimum tillage (L2) 170.

Several siliquae per plant under polythene mulch (M3) were significantly higher than in other mulch treatments. Several siliquae per plant under Tree leaves mulch (M4) and No mulch (M1) was found to be statistically at par with rice straw mulch (M2) and tree leaves mulch (M4) was found to be statistically at par with No mulch (M1). A maximum number of siliquae per plant was observed

in polythene mulch (M3) 189 and a minimum number of siliquae per plant was observed in No mulch (M1) 169. This might be due to the lesser weed competition for nutrients, moisture, space and sunlight at flowering and siliquae development stages which reduced the abscission of flowers and siliquae by mulching. This observation was supported by the work of Yadav (2006) and Anand *et al*. (2020). A maximum number of siliquae per plant was recorded in a combination of (L1M3) with 197 which was received in Conventional tillage + Polythene mulch and a minimum number of siliquae per plant was recorded in a combination of (L2M2) with 164 which received in Minimum tillage + Rice straw mulch.

Table 1. showed that tillage practices had a significant effect on the seed yield of mustard. The maximum seed yield per hectare was observed in conventional tillage (1629 kg/ha) and the minimum seed yield per hectare was observed in minimum tillage (1559 kg/ha). Conventional tillage (L1) plot showed the maximum seed yield as compared to Minimum tillage (L2) plots in which effective tillage activities like ploughing and harrowing were done to prepare fine seed bed hence there was good growth and development of plants with effective root system which helped in obtaining good seed yield of the crop. This observation was supported by the work of Ishaq *et al.* (2001), Kumar *et al.* (2016), Mishra *et al.* (2019), Liu *et al.* (2020)

Seed yield per hectare under polythene mulch (M3) was significantly higher than Tree leaves mulch (M4) and No mulch (M1) but seed yield per hectare under rice straw mulch (M2) was found to be at par with that of polythene mulch (M3). Seed yield per hectare under no mulch (M1) was found to be statistically at par with that of tree leaves mulch (M4). Maximum seed yield per hectare was observed in polythene mulch (1730 kg/ha) and minimum seed yield per hectare was observed in no mulch (1445 kg/ha). Maximum seed yield was recorded in a combination of (L1M3) 1790 kg/ha which was received in Conventional tillage + Polythene mulch and minimum seed yield was recorded in a combination of (L2M1) 1441 kg/ha which was received in Minimum tillage + No mulch. This might be due to the efficient utilization of resources like water, and nutrients and a better suppression of weed growth by mulching. Moreover, mulching helps to maintain proper soil temperature and its properties which enhance the growth of beneficial microbes in soil cumulatively resulting in higher yield. This observation was supported by the work of Yadav (2006), Anand *et al*. (2020) and Kader *et al*. (2019).

Data in Table 1 also showed that tillage practices had a significant effect on the stover yield of mustard. The maximum stover yield observed in Conventional tillage (L1) 4663 kg/ha was found to be significantly higher than that of Minimum tillage (4552 kg/ha).

Stover yield per hectare under Polythene mulch (M3) was significantly higher than Rice straw mulch (M2), Tree leaves mulch (M4) and No mulch (M1). Stover yield per hectare under Rice straw mulch (M2) was significantly higher than No mulch (M1). But stover yield per hectare under Tree leaves mulch (M4) was found to be statistically at par with that of Rice straw mulch (M2). Stover yield per hectare under Tree leaves mulch (M4) was significantly higher than No mulch (M1). Maximum stover yield per hectare was observed in Polythene mulch (M3) 4730 kg/ha and the minimum from No mulch (M1) 4453 kg/ha.

Maximum stover yield per hectare was recorded in a combination of (L1M3) 4790 kg/ha which was received in Conventional tillage + Polythene mulch whereas the minimum was recorded from the combination of (L2M1) 4441 kg/ha which was received in Minimum tillage + No mulch. Moreover, mulching helps to maintain proper soil temperature and its properties which enhance the growth of beneficial microbes in soil cumulatively resulting in higher yield. This observation was supported by the work of Yadav (2006) and Anand *et al*. (2020).

The maximum harvest index (%) observed in Conventional tillage (L1) 25.88% were found to be significantly higher than the Minimum tillage (L2) 25.49%. The harvest index under Rice straw mulch (M2) was significantly higher than Tree leaves mulch (M4) and No mulch (M1). But the harvest index (%) obtained under Polythene mulch (M3) was found to be statistically at par with that of Rice straw mulch (M2). The maximum harvest index was observed in Rice straw mulch (M2) at 26.88% and the minimum harvest index was observed in Tree leaves mulch (M4) at 24.45%. This may be due to the better allocation of photosynthates from source to sink by mulching Yadav (2006). Maximum harvest index was recorded in a combination of (L1M2) 27.50% which was received in Conventional tillage +Rice straw mulch and minimum harvest index was recorded in a combination of (L1M4) 24.13% which was received in Conventional tillage + Tree leaves to mulch.

Data in Table 1 showed that tillage practices had a significant effect on the oil yield of Indian mustard. The maximum oil yield (kg/ha) recorded in Conventional tillage (L1) 621 kg/ha was significantly higher than Minimum tillage (L2) 588 kg/ha. This observation was supported by the work of Mishra *et al.* (2019). Oil yield under Polythene mulch (M3) was significantly higher than Tree leaves mulch (M4) and No mulch (M1). But the oil yield obtained under Rice straw mulch (M2) was found to be statistically at par with that of Polythene mulch (M3). Oil yield under Rice straw mulch (M2) was significantly higher than Tree leaves mulch (M4) and No mulch (M1). Maximum oil yield was observed in Polythene mulch (M3) 666 kg/ha and minimum in No mulch (M1) 553 kg/ha. Maximum oil yield was recorded in a combination of (L1M3) 692 kg/ha which was received in Conventional tillage + Polythene mulch and minimum harvest index was recorded in a combination of (L2M4) 548 kg/ha which was received in Minimum tillage + Tree leaves to mulch.

Table 1. Growth and yield of rainfed Indian mustard under different tillage practices and mulching

Treatment	Plant height (cm)	Branches/plant	No. of siliqua / plant	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest Index	Oil yield (kg/ha)
Tillage								
Conventional Tillage (L_1)	151.17	5.29	185	4.69	1629	4663	25.88	621
Minimum Tillage (L_2)	137.25	4.08	170	4.45	1559	4552	25.49	588
S.Em(±)	2.23	0.12	2.38	0.03	11.47	14.82	0.03	4.44
C.D.(p=0.05)	13.62	0.78	14.50	0.19	69.79	90.20	0.18	27.02
Mulching								
No mulch (M_1)	136.17	4.43	169	4.55	1455	4453	24.63	553
Rice straw mulch (M_2)	145.33	4.76	179	4.52	1706	4643	26.88	646
Polythene mulch (M_3)	157.50	4.91	189	4.67	1730	4730	26.78	666
Tree leave mulch (M_4)	137.83	4.63	171	4.55	1484	4604	24.45	554
S.Em(±)	3.00	0.10	3.12	0.16	12.36	20.66	0.20	8.15
C.D.(p=0.05)	9.24	0.32	9.63	NS	36.15	63.67	0.62	25.12
Interaction (Lx M)								
S.Em(±)	4.24	0.14	4.42	0.23	17.51	29.22	0.28	11.53
C.D.(p=0.05)	13.07	0.46	13.61	NS	53.96	90.05	0.87	35.53

Table 2. Economics and Energy of rainfed Indian mustard under different tillage practices and mulching

Treatment	B:C ratio	Energy use efficiency	Energy productivity (kg/MJ)	Specific energy (MJ/kg)
L_1M_1	0.54	4.68	0.30	03.32
L_1M_2	0.71	1.26	0.07	12.64
L_1M_3	0.03	3.07	0.19	05.16
L_1M_4	0.57	1.10	0.07	14.10
L_2M_1	0.63	4.88	0.31	03.18
L_2M_2	0.72	1.20	0.07	13.11
L_2M_3	0.10	5.03	0.19	05.20
L_2M_4	0.66	1.09	0.07	14.22

*L_1 – Conventional Tillage ; L_2 – Minimum Tillage

*M_1 – No mulch ; M_2 – Rice straw mulch ; M_3 – Polythene mulch M_4 – Tree leave mulch

The highest benefit-cost ratio (0.72) was recorded in Minimum tillage + Rice straw mulch because there was less input cost for tillage or ploughing activities and mulching material cost. Hence the minimum cost of cultivation resulted in the highest B: C ratio. By adopting Minimum tillage with Rice straw mulch maximum benefits can be achieved. This might be due to the minimum cost of cultivation to produce high-crop produce. Such variations in economics among different treatments in tillage and mulching were also reported by Mondal *et al*. (2008), Jain and Jha (2012), Kumar *et al*. (2015) and Mounika *et al.* (2020).

Energy use efficiency

Among the different treatments, the highest energy use efficiency (4.88) was recorded in treatment L2M1 which was received in Minimum tillage + No mulch and the lowest energy use efficiency (1.09) was recorded in treatment L2M4 which was received in Minimum tillage + Tree leaves to mulch.

Energy productivity (kg/MJ)

Among the different treatments the highest energy productivity (0.31 kg/MJ) was recorded in treatment L2M1 which was received in Minimum tillage + No mulch and the lowest energy productivity (0.07 kg/MJ) was recorded in treatment L2M4 which was received in Minimum tillage + Tree leaves to mulch.

Specific energy (MJ/kg)

Among the different treatments, the lowest specific energy (3.18 MJ/kg) was recorded in treatment L2M1 which was received in Minimum tillage + No mulch and the highest specific energy (14.22 MJ/kg) was recorded in treatment L2M4 which was received in Minimum tillage + Tree leaves to mulch.

The highest energy use efficiency, and energy productivity but lowest specific energy was observed in Minimum tillage with No mulch and energy use efficiency, and energy productivity but highest specific energy was observed in Minimum tillage with Rice straw mulch. This was due to the use of less amount of energy input to produce more amount of energy output. Such variations in energy among different treatments in tillage and mulching were also reported by Singh *et al.* (2018) and Choudhary *et al.* (2017).

CONCLUSION

From the economic point of view, the highest monetary benefits in terms of maximum B: C ratio can be obtained from the combination of Minimum tillage + Rice straw mulch. The highest energy use efficiency and lowest specific energy were found in the treatment combination of Minimum tillage +No mulch.

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Research Article

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Pattern of market arrivals and prices of soybean in Akola District of Maharashtra, India

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ABSTRACT
In this study, an attempt has been made to study the pattern of market arrivals and prices of Soybean in the Akola district of Maharashtra. The present study was based on the time series data of monthly prices and the arrival of Soybean collected from major APMC'S of Akola district for the period of 10 years i.e. from 2011 to 2020. The study was carried out by employing econometric tools like ADF test, Johansen's Multiple Co-integration test, ARCH-GARCH model and Granger Causality test used to study price volatility and co-integration among selected markets. The study reveals that there is an inverse relationship between prices and the arrival of Soybean in the selected market of Akola district. The selected markets for Soybean have long-run equilibrium relationship for the prices of Soybean and there exist co-integration among them. The volatility shocks in the prices of Soybean is quite persistent in the selected markets.
Keywords: Seasonal variation, cyclical variation, ADF test, ARCH-GARCH, Co-integration, price volatility.

INTRODUCTION

Agricultural Produce Market Committee (APMC) is the marketing board established by the state governments to eliminate the exploitation incidences of farmers by intermediaries, where they are forced to sell their produce at extremely low prices. The market information relating to market prices and arrivals over a period of time helps the farmers to decide on the future production pattern and sale of agricultural commodities in the market during a specific period. The price prevailing in the market is called the market price, which changes with the nature of the commodity.

The price fluctuation in agricultural commodities is a common phenomenon due to their seasonal nature of production, wide ecological imbalances compared to other crops and seasonal demand for agricultural commodities. Variability in the supply of many agricultural products subsequently leads to larger variation in market arrivals which shows much of the price fluctuation. Fluctuations in market arrivals largely contribute to price instability and price fluctuations of agricultural commodities, there is a need to have an understanding of the price behaviour over time.

Market integration is a powerful tool, which alters the decision of the producers and also the consumers. This kind of study helps the farming community to know the remunerative prices for their harvest and also widens the market for their produce. The price of agricultural products does not only decrease but also increasing the number of market arrivals therefore there is a need to have a perfect understanding of the behaviour of prices of different agricultural products and the responsiveness of market arrivals to price movements over a period of time. Therefore, the present study has been undertaken to study the seasonal and cyclical variations in prices and arrivals of the Soybean crop, stationarity and volatility in prices of the Soybean crop & co-integration and causality of price signals among selected markets of the Akola district.

MATERIALS AND METHODS

For the present study the time series data on monthly average prices and arrivals of Soybean crops for period from 2011 to 2020 were collected from the record of APMC'S markets namely Akola, Akot, Murtizapur and Balapur as the arrivals Soybean crop in this market were highest. The most widely used method of measuring seasonal fluctuations i.e method of moving average was used to calculate seasonal indices. The residual method of estimating cyclical movement in time series was used for estimating cyclical indices, after eliminating the seasonal variation and trend components. Before analyzing any time series data testing for stationarity is a pre-requisite. The stationarity of time series data of selected market prices of Soybean crops is tested by applying the Augmented Dickey-Fuller test (ADF). Johansen's Multiple Co-integration test is employed to determine the long rum relationship between the prices of selected markets of Soybean crops. In order to know the presence of price volatility the ARCH-GARCH analysis was carried out. Granger Causality test is a statistical tool which used F-test to know the cause and

effect relationship between the two-time series and this technique is employed to know the relationship between the prices of selected Soybean crop markets.

RESULTS AND DISCUSSION

Seasonal and Cyclical variation in prices and arrivals of Soybean crop

Seasonal indices for Soybean crop prices and arrivals

In order to analyze the long-run seasonal variation in prices and arrivals of soybean in the selected markets, seasonal indices for prices and arrivals were computed by adopting 12 months moving average method.

The seasonal indices of monthly prices and arrivals of Soybean in the selected markets are presented in table 1. The seasonal indices of monthly average prices of Soybean in Akola, Akot, Murtizapur and Balapur markets were worked out to study seasonal variations, which are presented in Table 1. The arrivals of Soybean start hitting in the market in the month of October and January. The peak period of arrivals is October to January. Due to large arrivals during this period the prices decline. The lean period is from July to September. The prices were recorded higher from April to September. Most of the traders release the stored stock of Soybean during this period in anticipation of making a profit.

Cyclical indices for Soybean crop prices and arrivals

The Cyclical Indices for Soybean prices and arrivals in Different Markets of Akola district were worked out for the period 2011-2020. From Table 1, it is observed that the cyclical variation observed in the arrivals of Soybean in the selected markets. It is seen from the table that the highest arrivals of Soybean were observed in the year 2015, 2016 in all selected markets of Akola district. The highest price indices were recorded in the year 2012, 2013, 2014, 2015 and 2016 in all selected markets.

Table 1. Seasonal indices for Soybean prices and arrivals in selected markets of Akola district

Months	Akola		Akot		Murtizapur		Balapur	
	Arrivals	Prices	Arrivals	Prices	Arrivals	Prices	Arrivals	Prices
Jan	127.04	97.10	102.59	102.14	132.99	96.97	132.47	90.57
Feb	82.30	97.51	62.81	96.62	131.11	97.90	58.84	93.54
Mar	58.25	98.94	27.41	98.97	39.28	97.81	42.59	94.33
Apr	52.88	105.92	30.28	102.44	56.41	106.25	47.28	106.89
May	51.32	106.14	36.16	104.93	31.13	107.27	40.85	106.59
Jun	42.79	96.58	36.17	101.73	47.26	102.07	70.20	103.90
Jul	32.06	108.15	28.25	102.06	16.75	104.99	30.96	107.42
Aug	29.57	105.51	31.48	100.68	19.42	104.50	23.46	103.63
Sep	22.92	98.39	54.35	101.44	28.35	101.95	14.78	104.10
Oct	266.21	92.29	316.25	92.84	231.95	92.22	216.21	92.18
Nov	249.76	95.53	285.99	96.02	251.48	92.28	314.03	96.84
Dec	184.92	97.93	188.25	100.14	213.87	95.79	208.33	100.00

Table 2. Cyclical indices for Soybean prices and arrivals in selected markets of Akola district

Years	Akola		Akot		Murtizapur		Balapur	
	Arrivals	Prices	Arrivals	Prices	Arrivals	Prices	Arrivals	Prices
2011	96.11	71.44	96.03	73.11	89.09	77.66	83.14	58.63
2012	86.59	111.02	77.86	107.34	86.42	108.99	125.04	115.05
2013	127.22	112.01	60.40	110.03	91.40	106.48	81.63	116.15
2014	81.46	117.43	60.47	119.21	109.94	114.57	91.35	120.60
2015	89.35	106.68	163.91	106.17	106.75	108.12	79.62	106.99
2016	121.58	102.00	185.25	99.64	91.11	103.22	121.36	104.75
2017	127.55	79.13	105.89	88.96	132.71	79.57	146.96	82.72
2018	73.18	98.15	59.35	96.51	125.33	98.08	84.65	97.23
2019	99.00	99.22	99.77	100.06	93.76	101.71	92.98	99.33
2020	97.97	102.91	91.06	98.97	73.49	101.60	93.26	98.55

Testing of stationarity and volatility in prices of Soybean crop.

The Augmented Dickey-Fuller (ADF) based unit root test is carried out to check the stationary of the time series price data from four representative selected markets of Soybean.

From the table 3 it was observed that at level with lag 1, the ADF values of Akola, Akot and Balapur were less than the critical level at 1% level of significance indicating the existence of unit root implied that the price series in Akola, Akot and Balapur markets were stationary and the ADF value of Murtizapur is above the critical level at 1% level of significance indicating the existence of unit root implied that the price series in Murtizapur market were non-stationary. The table further showed that in first difference with lag 1, the ADF values are lower than that of the critical value at 1% level of first difference. This implied that the price series become stationary at first-order difference level.

Table 3. ADF test results of Soybean prices for selected markets

Market	Level (ADF)	First Difference	Critical Value
Akola	-3.970	-13.597	
Akot	-4.340	-15.027	
Balapur	-4.676	-11.827	-3.486
Murtizapur	-3.205	-10.384	

Price volatility in prices of Soybean crop

Price volatility in Soybean prices

To assess the presence of price volatility in the prices of Soybean in Akola, Akot, Murtizapur and Balapur markets, ARCH-GARCH analysis was carried out and the results are presented in table 4.

The sum of Alpha and Beta (α+ β), indicated ARCH and GARCH effects for the given market. It was observed that among the selected markets, the sum of Alpha and Beta is nearer to 1 i.e., 0.869, 0.926, 0.916 and 0.883 for Akola, Akot, Murtizapur and Balapur markets respectively, indicated that the volatility shocks in the prices of Soybean are quite persistent for a long time in these markets.

Table 4. Results of ARCH-GARCH Analysis for Soybean prices for selected markets

Parameter	Akola	Akot	Murtizapur	Balapur
Alpha (α)	0.601	0.677	0.895	0.926
Beta (β)	0.268	0.248	0.021	-0.043
Sum of α & β	0.869	0.926	0.916	0.883

Market Co-integration and Granger Causality in prices of Soybean crop

Johansen multiple co-integration trace test was applied for indicating the long-run relationship between the price series of selected markets. Co-integration is used instead of regular regression method because of its capacity in dealing with non-stationary series. The test shows whether the Soybean crop markets are integrated or not. The results of the test are presented below.

Market Co-integration between Soybean prices of selected markets

From table 21 it was observed that the presence of four co-integration equations at 5% level of significance confirms that there existed a long-run equilibrium relationship between the selected markets in terms of Soybean prices. The results of Co-integration test showed four co-integration equations were significant at 5% level of significance which implied that there existed co-integration among the markets.

Table 5. Results of multiple co-integration analyses of Soybean prices for the selected markets

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	Critical Value 5%	Prob.**	Number of Co-integrating Equation CE (s)
None *	0.386	111.982	47.856	0	
At most 1 *	0.220	55.844	29.797	0	Four
At most 2 *	0.117	27.270	15.495	0.0006	
At most 3 *	0.107	13.004	3.841	0.0003	

Note: Trace test indicates 4 co-integrating equations significant at the 5 percent level of significance.

Table 6. Results of pairwise Granger Causality Test for Soybean prices

Null Hypothesis:	Obs	F-Statistic	Prob.
Akot does not Granger Cause Akola	118	3.408*	0.0365
Akola does not Granger Cause Akot		10.598*	6.00E-05
Balapur does not Granger Cause Akola	118	3.313*	0.04
Akot does not Granger Cause Balapur		6.937*	0.0014
Murtizapur does not Granger Cause Akola	118	1.276	0.2833
Akola does not Granger Cause Murtizapur		11.362*	3.00E-05
Balapur does not Granger Cause Akot	118	4.948*	0.0087
Akot does not Granger Cause Balapur		1.420	0.246
Murtizapur does not Granger Cause Akot	118	4.048*	0.02
Akot does not Granger Cause Murtizapur		6.421*	0.0023
Murtizapur does not Granger Cause Balapur	118	1.374	0.2574
Balapur does not Granger Cause Murtizapur		6.342*	0.0025

Note: - *denotes significant at 1% level of significance.

Causality of price signals between Soybean crop markets

Granger Causality test is a statistical tool which used F-test to know the cause-and-effect relationship between the two-time series and this technique is employed to know the relationship between the prices of selected principal crops markets. When a co-integration relationship is present for two price series, a Granger Causality Test (Granger, 1969) is used to analyse the direction of this co-movement relationship. The results of the test showing the relationship between Soybean crop markets were presented below.

Causality of price signals between selected Soybean markets

The results of the Granger Causality test showing the relationship of prices between selected Soybean markets are presented in table 6. It was revealed that there is bidirectional causality in Soybean prices between Akot and Akola, Murtizapur and Akot markets respectively. The prices of Balapur market exhibited unidirectional causality and affect prices of Akola and Akot markets. The prices of Akot market exhibited unidirectional causality and affect prices Balapur. The prices of Akola market exhibited unidirectional causality and affect prices Murtizapur. So, the influence of Akola market prices played a significant role over the other selected markets. From the, above discussion it can be concluded that Akola market can be considered as a lead market of Soybean and influence the prices of the remaining markets. Thus, a strong market integration of the four markets Akola, Akot, Murtizapur and Balapur established through the results of the analysis.

CONCLUSION

This study examined the pattern of Arrivals and Prices of Soybean crops in Akola district using annual data covering the period from 2011- 12 to 2020-21. It is noticed that the inverse relationship between prices and arrival of Soybean in the selected market of Akola district. The study revealed that the pattern of arrivals and prices was directly supported in decision-making by the farmers and various intermediaries.

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Research Article

OPEN ACCESS

Popularization of improved short-duration Rice variety Telangana Sona (RNR 15048) through Frontline Demonstrations in Nalgonda District, Telangana.

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ABSTRACT
Frontline demonstrations on rice (275 No) were carried out by Krishi Vigyan Kendra, Kampasagar during four *Kharif* seasons 2016 to 2019 in Nalgonda District, Southern Telangana Zone under Left Canal Nagarjuna Sagar Project command area with the main objective of assessing the performance of improved short duration rice variety Telangana Sona (RNR 1504) with latest crop production and protection technologies against farmer's practice. The improved practice comprised of improved short-duration rice variety RNR 15048, seed treatment, nursery management, recommended cultural practices at the time of transplanting, application of recommended dosage of fertilizers, adopted need-based production and protection measures that resulted in significantly higher yield (6790 kg ha^{-1}) with 12.0 percent increase yield in demonstration plots over the farmer's practice (6048 kg ha^{-1}) during four-year study period. The technology gap ranged between 0 to 350 kg ha^{-1} with a mean of 210 kg ha^{-1}. The lowest extension gap (518 kg ha^{-1}) was observed in *kharif* 2019 and it was the highest (1050 kg ha^{-1}) in *kharif* 2018. The average extension gap was 742 kg $ha^{-1}$and the technology index was in the range of 0.0 to 5.0% with a mean of 3.0%. The demonstrations recorded a higher gross return Rs. 1,18,815 ha^{-1} with a profitability of Rs. 67,190 ha^{-1} and additional net return Rs. 19,167.0 ha^{-1} as compared to farmer's practice. The mean benefit-cost ratio was 2.3 in demonstrations over the farmer's practice 1.8. The results based on a comparison between demonstrations and farmers' practice indicated that the yield, gross returns, net income, and benefit-cost ratio in frontline demonstrations were higher than in the local farmer's practice. The Farmers practice recorded lower yields and incurred higher expenditure as farmers used local varieties, applied overdose of fertilizers, and indiscriminate use of pesticides, spending more money on managing the pests and diseases.
Keywords: Rice, Frontline Demonstrations, Yield, Extension gap, Technology gap.

INTRODUCTION

Rice (*Oryza sativa* L) is the main staple food for more than half of the world's population (Babtunde *et al*. 2016). In India self-sufficiency in food grain production is mainly achieved through rice crop is being cultivated in an area of 43.78 m ha with a production of 118.43 m t and an average productivity of 2705 kg ha^{-1}while in Telangana rice occupies 3.2 m ha with a production 11.9 m t and an average productivity of 3700 kg ha^{-1}. In Nalgonda district, it is being cultivated in 2.8 lakh ha with a production of 9.6 L t and an average productivity 3440 kg ha^{-1}. The productivity of rice has increased from 2102 kg ha^{-1}in 2005-06 to 2705 kg ha^{-1}in 2019-20. Development of high-yielding short-duration rice varieties, adoption of improved and location-specific technologies, the rapid expansion of rice crops into nontraditional areas due to increased irrigation facilities, developed infrastructure, use of optimum dosage of fertilizers, and price policy support are the major factors for increased rice production in India (Singh *et al*. 2017). Frontline demonstrations (FLD) are the foremost effective and useful extension tool to demonstrate the latest improved technologies i.e., High Yielding Varieties (HYV), crop production and protection technologies, and management practices to be followed on farmer's fields developed at research stations. The field-level organizations are playing a major role in KVKs in the application of technology through the assessment, refinement, and dispersion of proven technologies under different agro-climatic situations or regions (Das, 2007). FLDs with proven technologies might minimize the adoption gap by yield enhancement.

Rice is the main crop under irrigated conditions in the Nagarjunasagar Left canal command area during both *kharif* and *rabi* seasons in the Nalgonda District, Southern Telangana. Farmers in the district cultivate mainly BPT 5204 (Samba Mahsuri) a long-duration variety and privately produced short-duration varieties like Ankur Pooja, HMT Sona, Kaveri Chintu, and Ankur Pooja Gold. Professor Jayashankar Telangana Agricultural University (PJTSAU), Hyderabad prioritized research in the area of crop improvement constantly to cater needs of the farming community of the state. The University released RNR 15048 (Telangana Sona) in 2016, a high-yielding short duration (120 -125 days) fine grain variety which is being extensively cultivated by the farmers of Telangana and Karnataka. RNR 15048 variety is suitable to late sown conditions i.e., after July 15th, and for delayed onset of monsoons and late release of canal water and is more preferred under contingency crop situations. The potential yield of this variety was 6500-7000 kg ha^{-1} and is resistant to blast, tolerant to BPH, but susceptible to panicle mites (Tamilazhaki *et al*., 2020).

The yield gap between potential yield and actual farm yield is very high due to cultivation in degraded low fertile soils (Ramachandra *et al*., 2019), non-adoption of high-yielding varieties, unawareness of the latest improved technologies, and biotic and abiotic stresses. Yield gap analysis can provide a basis for identifying better management strategies to improve the rice yield by reducing the gap between the potential and actual yield. The rice-based farming systems can reduce the yield gap and increase rice yield (Stuart *et al*., 2016). The low yields on farmer fields' are due to delayed sowing, non-availability of quality seed, unbalanced fertilizer application, hand weeding (Samant, 2017) and poor management practices, especially related to levelling, bunding, weed management, poor nutrient management, cultivation of low yielding crop varieties and high pest and disease incidence (Tanaka et al., 2017). Adoption of improved rice varieties and technologies to bridge the yield gap could improve the production and productivity of rice. Keeping given the above facts, the KVK Kampasagar has organized FLDs with improved short-duration fine grain rice variety RNR 15048 with the latest crop production and protection technologies to assess the performance and awareness of the latest improved technologies among the farming community in Nalgonda District, Telangana.

MATERIALS AND METHODS

A total of 275 no of frontline demonstrations in four villages i.e. Islavath thanda, Bhalunaik thanda, Sitya thanda, and Kapuvarigudem of Nalgonda District, Telangana were carried out by KVK, Kampasagar under Tribal Sub Plan (TSP) during *kharif* seasons only in 2016 to 2019. The KVK Scientists collected baseline data from farmers in each village and problems associated with short, medium, and late-duration rice varieties were discussed before the conduction of FLDs on rice. Later the KVK scientists explained the advantages of the cultivation of short-duration rice varieties and the adoption of the latest crop production technologies. Farmers were selected through group discussions, interaction meetings, awareness programmes, and field visits. Finally, a list of interested farmers was prepared and soil samples were collected for analysis in selected farmers' fields. The demonstrations were conducted in an area of 0.4 ha and the adjacent field was treated as farmers' practice. The demonstrations consist seed rate of 50 kg ha^{-1} of improved short-duration rice variety of Telangana Sona, sowing of green manure crop daincha @ 37.5 kg ha^{-1} followed by in-situ incorporation in the soil before transplanting of rice, seed treatment with Carbendazim @1g L^{-1} water, soil test based recommended dose of fertilizer application, application of pre-emergence herbicide Pretilachlor @ 1L ha^{-1}, adoption of need-based cultural practices viz., for every 2m a 30 cm alleyways formation at the time of transplanting, erection of pheromone traps @10 ha^{-1} at 25 days after transplanting (DAT) to monitor yellow stem borer moths, application of Carbofuran granules 3G @ 25 kg ha^{-1} to control yellow stem borer and leaf folder. In demonstration plots, farmers were advised to follow recommended improved package of practices as explained by KVK scientists compared with conventional methods adopted by farmers. The KVK scientists organized extension activities i.e., method demonstrations, farmer-scientist interactions, need-based training programs, and regular field visits to monitor the incidence of pests and diseases. Prior to harvest, a field day was organized to involve more participation of local farmers in the popularization of the technology.

Data was recorded on both demonstrations and farmer's practice and per cent increase or decrease yield over the check, gross returns, net returns, additional net returns, and benefit-cost ratio and also collected data on yield gap I (Technology gap), yield gap II (Extension gap) and technology index were calculated based on following formula were given by Sawardekar *et al*. (2003).

$$\text{Increase or decrease yield over Demonstration plot (\%)} = \frac{\text{Yield (kg ha}^{-1}\text{) - Farmer's practice yield (kg ha}^{-1}\text{) the farmer's practice}}{\text{Farmer's practice Yield (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Yield Gap I (kg ha}^{-1}\text{)} = \text{Potential Yield (kg ha}^{-1}\text{)} - \text{Demonstration Yield (kg ha}^{-1}\text{)}$$

$$\text{Yield Gap II (kg ha}^{-1}\text{)} = \text{Demonstration Yield (kg ha}^{-1}\text{)} - \text{Farmer's practice Yield (kg ha}^{-1}\text{)}$$

$$\text{Technology Index (\%)} = \frac{\text{Potential Yield (kg ha}^{-1}\text{) - Demonstration Yield (kg ha}^{-1}\text{)}}{\text{Potential Yield (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Additional net returns (Rs.ha}^{-1}\text{)} = \text{Demonstration net returns (Rs.ha}^{-1}\text{) - Farmer's practice net returns (Rs.ha}^{-1}\text{)}$$

RESULTS AND DISCUSSION

Grain Yield:

Frontline demonstrations on short-duration rice variety RNR 15048 revealed significant mean grain yield (6709 kg ha^{-1}) in demonstration plots against farmer's practice (6048.0 kg ha^{-1}). The mean grain yields recorded were 6650, 7000, 6825 and 6685 kg ha^{-1}, respectively in demonstration plots and farmer's practice mean grain yields (5950, 6300, 5775 and 6167 kg ha^{-1}, respectively) were obtained during *kharif* 2016, 2017, 2018 and 2019. The highest grain yield (7000 kg ha^{-1}) was recorded in demonstration plots during *kharif* 2017 as compared to farmer's practice (6300 kg ha^{-1}) and the lowest yield was recorded in *kharif* 2016 due to scanty rainfall. The per cent increase in yield over the farmer's practice was 12.2%, 11.0%, 18.0% and 8.0%, respectively during 2016, 2017, 2018 and 2019, respectively with mean of 12.0% (Table 1). Increased grain yield in demonstration plots were due to the adoption of recommended improved short-duration fine grain variety RNR 15048, seed treatment with Carbendazim @1g L^{-1} water, in-time sowing, nursery raising after July 15th, timely transplanting (21 days age old seedlings), proper nursery management, timely application of weedicides, prophylactic and need-based plant protection measures. Practising better agronomic practices boosted grain yields in improved practice (Stuart *et al*., 2018). The higher yields in demonstrations were due to the adoption of improved varieties, intensive use of irrigation water and fertilizers, and expansion of irrigated areas (Mohanty and Yamano, 2017). These results are also in accordance with Jayalakshmi *et al*., 2021; Verma *et al*., 2016; Mitra *et al*., 2014; Prital Singh *et al*., 2020; Geetha *et al*., 2017; Mishra, 2009; and Narendra Singh *et al*., 2021.

Technology gap:

During four years of study, the technology gap between the improved practice and farmer's practice ranged from 0 kg ha^{-1} to 350 kg ha^{-1} with an average 210 kg ha^{-1} (Table 1) and the wide technology gap could be due to changes in the agro-climatic conditions, differences in managerial abilities across the farmers, farm instructional facilities available at different locations, and soil heterogeneity (Ravi Kumar *et al*., 2018). Most farmers have not followed the recommended package of practices, the latest improved technologies and recommended dose of chemicals, fertilizers, pesticides, and weedicides in rice crops from sowing to harvesting. Singh *et al*. (2021) reported that the use of the latest scientific technologies and the full recommended package of practices gave higher yields and net returns. Singh *et al*., (2020) also observed a wider technology gap between improved and farmers' practices in chickpea frontline demonstrations.

Extension gap:

The Extension gap of 700 kg ha^{-1}, 700 kg ha^{-1}, 1050 kg ha^{-1} and 518 kg ha^{-1}, respectively were recorded during *kharif* 2016, 2017, 2018 and 2019, respectively with a mean of 742 kg ha^{-1} (Table 1). The highest extension gap was observed in 2018 and it was low in 2019. The extension gap emphasized the importance of educating the farmer's through various extension methods i.e., training and method demonstrations to adopt improved latest agro technologies to lessen wide extension gap and adoption of the latest crop production technologies would change these alarming trends of galloping of extension gap. Adoption of improved transfer of technologies in demonstrations resulted in higher yields than farmers' practice. The extension gap can be bridged by encouraging the farmers to adopt improved practices while refining or modifying the existing technology by the concerned scientists to address the socioeconomic and environmental issues that can bridge the research gap (Ramachandra *et al*., 2019). Similar results were reported by Singh *et al*. (2021) in rice, Singh *et al*. (2021) in wheat crop, and Mamata *et al*. (2020) in wheat crop.

Technology index:

The technology index shows the feasibility of evolved technology on the farmer's fields. The lower value of the technology index, the higher the feasibility of the technology. The technology index of 5.0%, 0.0%, 2.5% and 4.5%, respectively were observed in *kharif* 2016, 2017, 2018 and 2019. The average technology index was 3.0% during the four years of the FLD programs (Table 1) which shows the efficacy of good performance of technical intervention adoption. This will accelerate the adoption of demonstrated technical intervention to increase the yield performance of rice and these results were in accordance with Deka *et al*. (2018)**.**

Economics:

Data on economic parameters like gross returns, cost of cultivation, net returns, and benefit-cost ratio were presented in Table 2. Higher gross returns of Rs. 1,10,390.0 ha-1, Rs. 1,19,700.0 ha^{-1}, Rs. 1,22,168.0 ha^{-1} and Rs. 1,23,004.0 ha^{-1}, were recorded in demonstrated plots as compared to Rs. 98,761.0 ha^{-1}, Rs. 1,07,730.0 ha^{-1}, Rs. 1,03,373.0 ha^{-1} and Rs. 1,13,473.0 ha^{-1}, respectively on farmer's practice during *kharif* 2016, 2017, 2018, 2019, respectively. The overall mean of four years indicated the average gross return was significantly high in demonstration plots (Rs. 1,18,815.5 ha^{-1}) over the farmer's practice (Rs. 1,05,836.5 ha^{-1}). The higher gross returns in demonstrations were due to higher yields and low cost on inputs and adoption of recommended package of practices. Cost of cultivation was low in improved practice because of adoption of recommended agronomic and cultural practices, whereas in farmer's practice the expenditure was more on the cost of inputs due to recommendations of local pesticide dealers.

The net returns of Rs. 57,265 ha^{-1}, Rs. 69,075 ha^{-1}, Rs. 79,293 ha^{-1} and Rs. 72,129 ha^{-1} were higher in improved practices as compared to farmer's practice (Rs. 40,020 ha^{-1}, Rs. 51,480.0 ha^{-1}, Rs. 44,123 ha^{-1} and Rs. 56,473 ha^{-1}, respectively) during *kharif* 2016, 2017, 2018 and 2019. The mean net return was Rs. 67,191 ha^{-1} in demonstrations while in farmer's practice it was Rs. 48,024 ha^{-1}.

Table 1. Yield performance of rice variety RNR 15048 under Frontline demonstrations (FLDs) vs Famer's practice (FP)

Year	No of Demos	Potential yield (kg ha^{-1})	Yield (kg ha^{-1})		Increase in yield over the control (%)	Technology Gap (kg ha^{-1})	Extension Gap (kg ha^{-1})	Technology Index (%)
			Demo	Check				
2016	25	7000	6650.0$^{\#}$	5950.0$^{\#}$	12.0	350.0$^{\#}$	700.0$^{\#}$	5.0$^{\#}$
2017	25	7000	7000.0$^{\#}$	6300.0$^{\#}$	11.0	0.0$^{\#}$	700.0$^{\#}$	0.0$^{\#}$
2018	200	7000	6825.0$^{\#\#}$	5775.0$^{\#\#}$	18.0	175.0$^{\#\#}$	1050.0$^{\#\#}$	2.5$^{\#\#}$
2019	25	7000	6685.0$^{\#}$	6167.0$^{\#}$	8.0	315.0$^{\#}$	518.0$^{\#}$	4.5$^{\#}$
Average	275	7000	6790.0	6048.0	12.0	210.0	742.0	3.0
t-value			5.27					
p-value			0.002*					

$^{\#}$ Mean of 25 famers; $^{\#\#}$Mean of 200 farmers; *Significant at P=0.05.

Table 2. Economics and additional returns in rice variety RNR 15048 under Frontline demonstrations (FLDs) vs Farmer's practice (FP)

Year	Gross returns (Rs ha^{-1})		Cost of Cultivation (Rs ha^{-1})		Net returns (Rs ha^{-1})		Additional net returns (Rs ha^{-1})	B:C ratio	
	Demo	Check	Demo	Check	Demo	Check		Demo	Check
2016	110390.0$^{\#}$	98770.0$^{\#}$	53125.0$^{\#}$	58750.0$^{\#}$	57265.0$^{\#}$	40020.0$^{\#}$	17245.0$^{\#}$	2.1$^{\#}$	1.7$^{\#}$
2017	119700.0$^{\#}$	107730.0$^{\#}$	50625.0$^{\#}$	56250.0$^{\#}$	69075.0$^{\#}$	51480.0$^{\#}$	17595.0$^{\#}$	2.4$^{\#}$	1.9$^{\#}$
2018	122168.0$^{\#\#}$	103373.0$^{\#\#}$	51875.0$^{\#\#}$	59250.0$^{\#\#}$	70293.0$^{\#\#}$	44123.0$^{\#\#}$	26170.0$^{\#\#}$	2.4$^{\#\#}$	1.7$^{\#\#}$
2019	123004.0$^{\#}$	113473.0$^{\#}$	50875.0$^{\#}$	57000.0$^{\#}$	72129.0$^{\#}$	56473.0$^{\#}$	15656.0$^{\#}$	2.4$^{\#}$	2.0$^{\#}$
Average	118815.0	105836.0	51625.0	57813.0	67190.0	48023.8	19167.0	2.3	1.8

$^{\#}$Mean of 25 famers; $^{\#\#}$Mean of 200 farmers.

The maximum net return of Rs. 72,129 ha^{-1} was found in *kharif* 2019 due to variations in the price of agri-inputs and minimum support price for the produce. The average additional net return of Rs. 19,167 ha^{-1} was gained in demonstration plots and the benefit-cost ratio was higher in demonstrations when compared to farmer's practice during four years study period. The average benefit-cost ratio of 2.3:1 was found in demonstrations against 1.8:1 in the farmer's practice. The higher benefit-cost ratio in demonstration plots might be due to the cultivation of high-yielding improved short-duration rice variety with improved practices against the conventional practices. In farmer's practice, more money was incurred on the purchase of pesticides to control pest and disease incidence, over application of fertilizers, and also following traditional methods in paddy cultivation from sowing to harvesting. Whereas, improved practices followed the cultivation of recommended improved varieties, seed treatment with fungicides to control early stages of soil and seed-borne diseases and pests and recommended dose of weedicides, pesticides for managing weeds, pests, and diseases and optimum usage of fertilizers based on soil test results and the reduced cost on fertilizers might result in higher net returns and benefit-cost ratio (Singh *et al*., 2021). These results indicated that improved practices are more profitable, economically viable and beneficial to rice growers under local agroecological situations. Raj *et al*. (2014) reported that replacing old varieties with the latest improved varieties increases rice production and the net income of the farmer. Similar findings were observed by Verma *et al*., (2016); Mitra *et al*., (2014); Zamir Ahmed *et al*., (2014); Jayalakshmi *et al*., (2021); Singh *et al*., (2018); Deka *et al*., (2018); Singh *et al*., (2021); Narendra Singh *et al*., (2021) and Samant, (2014).

CONCLUSION

From this study, a difference in productivity levels between demonstrations and farmer's practices was noticed. In frontline demonstrations, cultivation of improved short-duration rice variety RNR 15048 and adoption of the latest crop production and plant protection technologies increased significantly grain yields, net returns, and benefit-cost ratio as compared to farmer's practice. Yield levels were higher in improved variety against local checks by disseminating the latest agro technologies through various extension methods and the farmers should be encouraged to adopt the recommended package of practices to get higher net returns. The extension and technology gaps were widened between improved and farmers' practices and to bridge the gap popularize recommended packages of practices with specific local recommendations, emphasizing the cultivation of improved varieties with

the latest agro technologies. Replacement of old varieties with improved varieties will increase the net income and productivity. Finally, it is evident that the rice variety RNR 15048 is found to be more suitable and fits well in the existing farming situations, and frontline demonstrations played a key role in the popularization of RNR 15048.

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Research Article

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Effect of Combined Application of Vermicompost and NPS Fertilizer Rates on Growth, Yield and Yield Components of Maize (*Zea mays* L.*)* at Toke Kutaye District, Ethiopia

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ABSTRACT
Maize is one of the major and important cereal crops in Western Shewa Zone, particularly, in the Toke Kutaye district. However, the yield of the crop is low mainly due to the low fertility status of the soils. Integrated use of vermicompost and NPS fertilizers is indispensable to improve this condition of the soil. In this context, a study was conducted in 2019/2020 to assess the effect of the combined use of vermicompost and NPS fertilizer on yield and yield components of maize. To achieve this objective field experiment was laid out in a randomized complete block design and replicated three times. The results of this study revealed that the current scenarios of maize production in Toke Kutaye district call for appropriate ways of adding nutrients to the soil to obtain optimum maize productivity. In response to this, the combined application of different rates of vermicompost and NPS fertilizer to soil significantly affected most parameters used for this investigation such as plant height, leaf number, leaf length, leaf area, stand count, ear length, and a number of ears per plant, thousand-grain weight, total above-ground dry biomass and grain yield of maize. Moreover, the combined form of NPS blended fertilizer and vermicompost was applied and the result revealed that the sole application of recommended NPS fertilizer and vermicompost increased maize yield by 52.27 and 55.72% over control treatments, respectively. Besides this, the combined use of vermicompost and NPS fertilizer by the rating of half of the recommended rate of both fertilizers increased maize yield by 60.05% over the control treatment. This indicates that the best option for soil fertility management is integrated soil fertility management that involves the combined use of vermicompost and NPS fertilizers as nutrient sources than the strategy of using organic or inorganic amendments alone. Then, it could be concluded that the use of blended NPS fertilizer at 50 kg $ha^{-1}$with supplemental vermicompost at 5 t ha^{-1} to Jibat variety is the realistic approach to address the problem of low productivity of maize in the study area and other similar agroecology. Based on the findings and conclusions of this study it can be recommended that farmers in the study area should, therefore, be advised to use this variety and combined use of vermicompost and NPS fertilizer at a rate of 5 t ha^{-1} VC +50 kg ha^{-1} NPS for sustainable maize crop production tentatively. Nevertheless, further studies are needed to recommend agronomical optimum and to measure the long-term effects of the integrated soil fertility management techniques in more seasons, soil types and crop varieties before giving a conclusive recommendation.
Keywords: Grain yield; NPS fertilizer; Soil fertility; Vermicompost.

INTRODUCTION

Maize is an important staple food crop and the most useful cereal crop next to tef in western Ethiopia (Abera *et al.*, 2013). Maize is one of the most important cereal crops in the world which is ranked as the third major cereal crop after wheat and rice. The USA, China and Brazil contribute 63% to the global maize production and topped the list of maize-producer countries which includes Ukraine, Argentina, India, Mexico, South Africa and Canada with an amount of about 351 million metric tons (FAO, 2011). Its centre of origin also is located in America, particularly, Mexico, and spread throughout North and South America (Vigouroux *et al*., 2011). In Africa, it is a popular and widely cultivated food crop since its introduction to the continent around 1500 A.D. (Zamir, 2013). The main maize producers in Africa include Kenya, Tanzania, Zambia, Zimbabwe and Ethiopia (Kidist *et al*., 2013; Mitiku and Asnakech, 2016). Likewise, in Ethiopia maize is the second most widely cultivated crop next to tef and it is grown as a subsistence crop in the mid-altitudes (1500–2000 m above sea level) in southern, south-central, and southwestern parts of Ethiopia (Tsedeke *et al*., 2015). It accounts for the largest share in total production and the total number of farm holdings involved among cultivated cereals in Ethiopia. In the 2011 cropping season, maize accounted for 28 per cent of the total cereal production, and approximately 9.3 million smallholder farmers in

Ethiopia grow maize, mainly for human consumption (Demeke, 2012; Tsedeke *et al*., 2017).

Maize covers nearly 197, 204, 250 million hectares of the world's arable land (FAO STAT, 2017). It is also the most widely grown staple food crop in eastern Africa occupying more than 15.7 million ha (FAO, 2019). According to a report by the Central Statistical Agency (CSA, 2020), around 17.68% of Ethiopian cultivated land is covered by maize. The average yield of maize on research field in Toke Kutaye District, in particular, is 7.59 t ha^{-1} (Tolera and Tesfaye, 2021) and that in the country is 4.2 t ha^{-1} (CSA, 2019), which is lower than the world's average yield of 5.8 t ha^{-1} (Kumar and Kumar, 2017) as the result of the inadequate soil fertility of the country.

The most limiting factors for sustainable maize production in smallholder farming systems of Ethiopia are low soil fertility (Okoko and Makworo, 2012). In line with these most Ethiopian soils are deficient in nutrients especially nitrogen and phosphorus due to continuous and intensive mono-cropping of maize production, removal of crop residue, insufficient inputs of replacement nutrients, accelerated soil erosion caused by inappropriate land uses and poor soil management practices, as well as unbalanced fertilization, also aggravate soil organic matter and nutrient depletion (IFPRI, 2010; Sanchez, 2015).

However, organic farming or chemical fertilizers are used as a solution for such situations, there are some problems related to chemical fertilizers such as inadequate supply or even unavailability of fertilizer at the time of need and becoming very costly for farmers to apply the full recommended rates. Further, the continuous use of chemical fertilizer creates a potential polluting effect on the environment. On the other hand, the sole application of organic matter is constrained by access to sufficient organic inputs, low nutrient content, high labor demand for preparation and transporting. It has been reported that application of integration of organic sources with synthetic sources of nutrients not only supply essential nutrients but also improves soil physical properties, sustainable maize production and reduces environmental hazards. In this regard, study conducted in southern Ethiopia, by using integrated use of coffee by products and N fertilizer increased N uptake and grain yield of maize (Fanuel and Gifole, 2013). Similarly, the combined use of vermicompost and NPS fertilizers affect some of maize growth parameters such as height, yield and yield components more than chemical fertilizer or vermicompost alone (Alam, 2014).

Integrated use of organic and chemical fertilizers is beneficial in improving soil fertility and sustainable productivity better than the application of either organic or inorganic NPS fertilizer alone (Endris and Dawid, 2015). Tilahun and Tamada *(*2019) also stated that neither inorganic nor organic fertilizers alone can result in the sustainable productivity of maize crops. In this line, the integration of organic and inorganic sources such as vermicompost and NPS fertilizer can improve soil properties and sustain crop yields without degrading soil fertility status. Besides this, the recommended rate of blended NPS with vermicompost has not been described and the combined effect of blended NPS and vermicompost on maize production particularly in Toke Kutaye district has not been well studied so far. It is pertinent to study the response of maize crop to the combined application of vermicompost and NPS fertilizer. Hence, this calls for a need for research on the improvement of soil fertility status and the response of maize crops to the combined use of vermicompost and NPS chemical fertilizers. Therefore, this study was conducted to assess the effect of blended NPS fertilizer supplemented with vermicompost on growth, yield components and yield of maize in the Toke Kutaye district.

MATERIALS AND METHODS

Description of the Study Area

Location and area coverage

The field experiment was conducted at Ambo University Guder Mamo Mezemir Campus, which is found in Toke Kutaye district of Western Shewa Zone, Oromia Regional State at a distance of approximately 138 and 12 km, respectively, from Addis Ababa and Ambo town. Toke Kutaye district is located at a latitude of 8° 49'0"-9° 5'30"N and a longitude of 37° 26'0''-37° 57'30"E. The district is bounded by Liban Jawi district in the west, Midakegn district in the north, Ambo and Amaya district in the east and Dire Inchini district in the south. Toke Kutaye district has a total area of 51,313.19 hectares (Tolera *et al*., 2020).

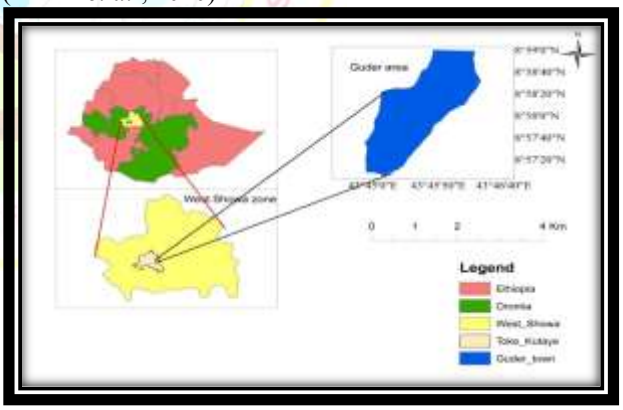

Figure 1. Area map of Toke Kutaye Woreda in Ethiopia

Climate and topography of the study area

The study area consists of three agro-climatic zones: lowland (desert/beraha), middle (subtropical/woina dega), and highland (temperate/dega) (Tolera *et al*., 2016). These agro climatic divisions covered 18%, 57% and 25%, respectively. The annual rainfall ranges from 800-1100 mm. The district has a unimodal rainfall pattern in which rain is received from April to September, but the highest rains are received from June to August. The minimum and maximum temperatures of the district are 10 and 29°C, respectively. The altitude of

the area ranges from 1,880-3,194m above sea level (MAARC, 2019).

Geological parent materials and soil types

The soils of the study area are developed from different parent materials such as schist, granite, gneiss and basalt through weathering (Adane *et al*.,2020). According to Abera and Belachew (2011) the dominant soil type of a study area is vertisol. Furthermore, soils of the study area are strong to moderately acidic in reaction (pH of 5-5.5), with loose and friable consistence, deep and well drained and clay in texture.

Population, land uses and farming system

The total population of the district was about 125,658 where 62,860 (50.2%) were male and 62,798 (49.8) female of which about 98,856 (78.6%) of the population live in a rural area and 49,456 (39.35) male and 49,409 (39.32%) female and 26,793 (23.3%) live in urban. The total number of household farmers in the district was 25,166 of which 21,855 (86.8%) were male and 3,311 (13.2%) female (Aman, 2018). Religious activity which practised in the study area included Christianity with different denomination like protestant, orthodox, catholic, Adventist, Muslim and Wakefata being dominant. Toke Kutaye district has 35, 209 ha of cultivated land, 8,017 ha of grazing land, 2,846 ha of forest land, and 5,241 ha occupied by construction. A mixed crop-livestock system that involves crop production and animal husbandry is the predominant farming system in the study area. The main crops grown in the study area are maize, barley, wheat, tef, bean and oil seeds such as nug (Tariku *et al*., 2018). The major livestock reared are cattle, poultry, mule, horse, sheep, and goats. Intercrop, grazing and livestock production land use and traditional farming system are used in the district. Oxen power is the main power source for ploughing and threshing activities.

Methods of Study

Compost materials and vermicompost preparation procedures

Vermicompost was prepared as a head of field experiment by using earthworm and organic materials such as green plants, animals dung, pulse straw and inputs like cattle manure was used as bedding materials for Vermicomposting and bulking in the composting process. For vermicompost preparation, vermicompost bin with 2m length, 1m width and 1m deep was used. The bin has a lid to keep out ants, birds, flies and rodents and holes in the bottom a quarter inch or smaller for ventilation and drainage. Since worms like moderate temperature, the bin was placed in a shady location where it was not overheated (Lazcano *et al*., 2008).

At the bottom of the bin vermicompost material such as green plants, animal's dung, pulse's straw was added as bedding material. Then, compost materials were placed in stacks according to the following sequences of a layer of crop residues/green plants (20 cm) or 60%, a layer of manure (animal dung, sheep manure) (5-10 cm) or 30%, and a layer of topsoil (2-4 cm) or 10% (Suparno, 2013). Some layer of soil spread over it again and worms are introduced to the bin. The materials in the bin were turned every 3 days and regular watering was done to keep moisture and make the materials soft for the worms. After composting was completed new stack of compost materials was prepared for one side of the bin and the worms were gradually moved to the new stack by leaving the finished vermicompost. Then, the finished vermicompost was harvested and it is dark in colour light and free from any unpleasant odor (Ahmadabodi *et al*., 2011).

Experimental treatments and design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with nine treatments and three replications. The treatment consists of a combination of vermicompost and chemical NPS fertilizer. The recommended rate of Vermicompost 10 t $ha^{-1}$was used depending on recommendations given by different researchers (e.g.Fekadu *et al*., 2014). While, the rate of NPS fertilizers was determined from the local blanket recommendation that is in use by the local farmers. The recommended rate of NPS fertilizer is 100kg ha^{-1} in place of DAP (Di-ammonium phosphate) as per suggestion by ATA (2014). The treatments consist of control (no fertilizer), 100% of recommended NPS, 100% recommended vermicompost, 5 t ha^{-1} VC +50 kg ha^{-1}NPS, 5 t ha^{-1} VC+100 kg ha^{-1} NPS, 10 t ha^{-1} VC +50 kg ha^{-1}NPS, 10 t ha^{-1} VC+100 kg ha^{-1} NPS, 15 t ha^{-1} VC+50 kg ha^{-1}NPS and 15 t ha^{-1} VC+100 kg ha^{-1}NPS were laid out in a randomized complete block design and a total of nine treatments with three replication.

Experimental procedures and field management

The field experiment was conducted to evaluate different rates of NPS fertilizers integrated with vermicompost using maize crop of FS53xFS67xKit23 Jibat variety which was released from Ambo Plant Protection Research Centre and its yield potential on the research field is 6.5-7.8 t $ha^{-1}$and on farmers' fields is 4.5-5.5 t ha^{-1} (MoARD, 2009). The total land area selected for the experiment was 352.35 m^2 (26.1 m x 13.5 m). It was divided into three blocks and each block was divided into nine sub-plots. The spacing between blocks, plots, rows and plants were 1, 0.5, 0.7, and 0.3 m, respectively. Land preparation (seed bed preparation) of the experimental test field was done by ploughing three times with traditional oxen-driven practices. Ploughing was done twice per week intervals to destroy the emerging weeds. Harrowing was done after ploughing to further pulverize larger soil aggregates.

Vermicompost was applied by hand in the row and thoroughly mixed with the top surface layer soils of each plot one month before planting because immediate sowing of the crop after vermicompost application sometimes sufficient time must be permitted for more decomposition before sowing of crops. Inorganic fertilizers were placed in a hole 5 cm from the seeds in the furrow covered with a thin layer of soil then followed by the sowing of seeds and then covered again with soil to have close contact between the seed and the soil, thus, would facilitate uniform germination. Maize crop was

hand drilled at a recommended seeding rate of 20-25 kg ha^{-1}(Okoko and Makworo, 2012). Sowing was conducted in the first week of April 2019. All management aspects were done by adopting the recommended agronomic practices of maize production and local practices.

Soil sampling and analysis

To determine soil physicochemical properties, composite and core soil samples were drawn from the top layer of each experimental unit before and after planting. Soil samples from 0-30 cm depth were collected before maize planting for analysis of selected soil physicochemical properties planting. A total of three composite samples were collected from the three blocks. Soil samples were collected by auger from nine plots and thoroughly mixed to make one composite sample per block. At the same time, undisturbed core samples from 0-30 cm depth layers were also collected randomly by taking one sample per block using the core method to determine soil bulk density before planting.

For soil sampling, after harvesting from each plot an auger was used to sample five randomly selected spots per plot. These five subsample soils were combined into one composite soil sample per plot for investigating the soil properties of each treatment. Similarly, undisturbed core samples from 0-30 cm depth layers were also collected to determine the soil bulk density of each plot. The collected soil samples were bagged, labelled and transported to the laboratory for preparation and analysis of soil properties. A sufficient amount of composite soil samples was air-dried and ground to pass through a 2 mm sieve in preparation for the analyses of the selected physicochemical properties following standard laboratory procedures (Sahlemedin and Taye, 2000). A portion of the disturbed soil samples was taken and sieved using a 0.5 mm diameter for the determination of the organic matter and total nitrogen. Soil sample preparation and analysis were done at Holeta agricultural research centre. The samples were analyzed for particle size distribution, soil texture, bulk density, particle density, porosity, moisture content, pH, available phosphorus, available potassium, available sulfur, total nitrogen, organic carbon, and cation exchange capacity.

Laboratory analysis of soil:

Soil physical properties

Particle size distribution was determined by the hydrometer method (Day, 1965). Then, the soil was assigned to a textural class using the USDA soil textural triangle (Soil Survey Staff, 1999). Bulk density was determined using the core method as described by Jamison (1950). Particle density was described using the pycnometer method following procedures described by Rao *et al*. (2005). Total porosity was calculated from the values of bulk density and particle density using the method described by Rowell (1994). Soil moisture content was determined using the gravimetric method as described by Reynolds (1970).

Soil chemical properties

Soil pH was measured in a soil-water suspension by the glass electrode pH meter (Peech, 1965) at 1:2.5 soil-to-water ratios. Soil organic carbon was determined using the Walkley - Black wet oxidation procedure (Walkley and Black, 1934) and the soil organic matter content was determined from the organic carbon as suggested by Nelson and Sommers (1996). Total nitrogen content in the soils was determined using the Kjeldahl procedure (Jackson, 1958). Available P in the soil samples was extracted by using the Bray II method (Bray and Kurtz, 1945). The Phosphorus extracted with this method was measured by spectrophotometer following the procedures described by Murphy and Riley (1962). Available sulfur was extracted with ammonium acetate (1N NH_4OAc) and determined using the gravimetric determination method as described by Warman and Sampson (1992). Exchangeable potassium was extracted with neutral normal ammonium acetate and the content of potassium in the extract was estimated by a flame photometer (Jackson, 1973). Cation exchange capacity (CEC) was determined after extracting the soil samples by ammonium acetate (1N NH4OAc) at pH 7 using the methods described by Chapman (1965). The result of the analysis is presented in Table 1 below.

Table 1. Selected soil physicochemical properties of an experimental site before planting

Physical properties	BD ($g.cm^{-3}$)	PD ($g.cm^{-3}$)	Total porosity (%)	Soil moisture (%)	soil texture	PSD (%)		
						Sand	Silt	Clay
Mean values	1.28	2.65	51.6	36.9	Clay	15.1	35.3	49.6

Chemical properties	pH	OC (%)	TN (%)	C: N (%)	av. P (ppm)	av. S (ppm)	ex. K (cmol/kg)	CEC (cmol/kg)
Mean values	5.24	1.61	0.14	11.5	9.01	2.97	0.42	21.14

Table 2. Chemical composition of vermicompost used for this study

Physicochemical parameters	Moisture (%)	pH	OC (%)	Nt (%)	C: N	P (%)	K(cmol/kg)
Mean values	43.2	6.85	11.76	1.64	7.17	2.26	1.14

Chemical Composition of vermicompost

To determine the composition of the vermicompost, samples of 100 g were collected for chemical analysis. Compost samples were analyzed for chemical parameters such as pH, total organic carbon, total Nitrogen, potassium and Phosphorus. The pH of vermicompost was determined by the method described by Ndegwa and Thompson (2001). Total organic carbon is described by Okalebo *et al*. (2002) method. The total Nitrogen content of vermicompost was determined using Kjeldahl procedure (Bremner and Mulvancy, 1982). The total phosphorus content was determined by the method described by Olsen (1954) and the total potassium content was determined as described by Hesse (1971). The result of the analysis is presented in Table 2.

Agronomic Data Collection

Agronomic data that were collected during the field experiment include plant height, leaf area, leaf length, leaf number, stand counts, number of ears per plant, number of ears per hectare, ear length, 1000 grain weight, biomass yield and grain yield. For this purpose, six maize plants were pre-tagged and randomly selected from each plot for sampling.

Growth parameters

Plant height was measured as the height from the soil surface to the base of the tassel of six randomly taken plants from the net plot area at 75% physiological maturity. Leaf numbers were counted per plant for all available leaves from six maize plants. Leaf length was measured from the base of the leaf to the tip of the leaf of that plant. The leaf area of all available leaves of six plants per net plot was collected at 50% milking stage and leaf length and width were measured: Leaf Area (LA) = Length (cm) x Maximum width of leaf (cm) and was adjusted by a correction factor 0.75 (0.75 x LL x maximum leaf width) (Mihiretu,2014; Uzun and Celik,1999). Leaf area index was calculated as the ratio of total leaf area per six plants (cm^2) per area of land occupied by the plants (Radford, 1967).

Yield and yield components

Stand count was recorded per plot after thinning and at harvest from the net plot area. Several ears per plant was recorded from the count of six randomly taken plants in the central net plot area at crop harvest. A number of ears per hectare was recorded by counting the number of ear per plot and converting to hectare. Ear length was recorded from the measure of six randomly taken ears per net plot at harvest. 1000-grain weight was measured by weighing air-dried hundred maize grains. Grain yield, cobs of each plot were shelled and weighted to have grain yield per plot, then yield were converted from Kg/plot into hectare by adjusting to 12.5% moisture content. Biomass yield was recorded from each plot after harvesting and air drying the samples to constant weight.

Data analysis and Interpretation

Analytically determined soil physicochemical and agronomic data were subjected to analysis of variance using GLM procedures of the Statistical Analysis System Software (version 9.0) (SAS, 2004). Whenever the ANOVA detects significant differences ($P<0.05$) between treatments, mean separation was conducted using Fisher's Least Significant Difference (LSD) test (Gomez and Gomez, 1984). A simple correlation analysis was also conducted to identify useful associations among key soil and agronomic variables.

RESULTS AND DISCUSSION

Effect of vermicompost and NPS fertilizer on growth, yield components and yield of maize crop

Growth parameters

There were significant variations ($p<0.05$) among the combined rate of vermicompost and NPS fertilizers on plant height, leaf number, leaf length and leaf area of maize crop after the field was incorporated with different doses of vermicompost and NPS fertilizers (Tables 3-5).

Plant Height

Average maize plant height was significantly influenced by the application of vermicompost and NPS fertilizers. The highest value of plant height (263.70 cm) was observed from 10 t ha^{-1} VC + 100 kg ha^{-1} NPS fertilizer whereas the lowest value (188.67 cm) was found from the control plot (Table 3). This showed that increasing a combined dose of vermicompost and NPS fertilizer application to soil, increased plant height than that of control treatment, sole use of vermicompost and NPS fertilizer, and low rate of application. The variation in plant height due to different doses of amendments might be due to variations in the availability of major nutrients. Moreover, the increase in plant height concerning increased vermicompost and NPS fertilizer application rate indicates high availability of major plant nutrients and maximum vegetative growth of maize plants under a higher combination of vermicompost and NPS fertilizer. Further, chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to plants. Nutrient availability from organic sources might be due to microbial action and improved physical condition of the soil. In line with this result, Priya *et al*. (2014) reported that plant height was significantly affected by the complementary application of 100% NPK (120: 60:30 kg ha) fertilizers with 10 t ha^{-1} FYM. This finding was also supported by Manish *et al.* (2017) who demonstrated that the relatively highest values of plant height were recorded for plots fertilized with the highest doses of cow dung and NPK fertilizers.

Leaf Number

Combined application of vermicompost and NPS fertilizer increased leaf number of maize crop over control or sole application of each fertilizer. Accordingly, the highest value of leaf number (14.98) was recorded from 10 t ha^{-1} VC + 100 kg ha^{-1} NPS fertilizer while the lowest value (12.68) was recorded from the control treatment (Table 3). The highest value was recorded due to the availability of a sufficient amount of nutrients to plant growth through vermicompost and NPS fertilizer. Jeet (2012) also reported a significantly higher number of green leaves

per plant with the application of increasing levels of organic and inorganic fertilizers. Moreover, this finding was supported by Singh and Singh (2016) who reported increases in leaf number with increasing doses of organic and inorganic fertilizers applied.

Leaf Length

Combined use of vermicompost and NPS fertilizer rate increase leaf length of the maize plant. The highest value of leaf length (86.08 cm) was recorded from 10 t ha^{-1} VC+100 kg ha^{-1}NPS fertilizer while the lowest value (73.73 cm) was also recorded from the control treatment (Table 3). This might be attributed to the more vegetative growth of maize crops due to improved nutrient availability. In the same manner improvements in the growth and yield of maize crops due to vermicompost and NPS fertilizer application was also reported by Tolera *et al* (2016).

Leaf Area

The results presented in Table 3 showed that as the vermicompost and NPS fertilizer combination rate increased leaf area of maize also increased. The highest value of leaf area (830.58 cm^2) was recorded from 10 t ha^{-1} VC + 100 kg ha^{-1} NPS fertilizer while the lowest value (73.73 cm) was also recorded from the control treatment. This might be due to the more vegetative growth of maize crops and the development of vermicompost and blended fertilizer which increased the utilization of applied nutrients by the crop. In agreement with this result, Dagn (2016) stated that vermicompost produced significant improvements in leaf area.

Table 3. Effect of vermicompost and NPS fertilizer on plant height, leaf number, leaf length and leaf area of maize crop

Treatments	Plant height (cm)	Leaf Number	Leaf length (cm)	LA (cm^2)
T_1	188.67^{e}	12.68^{f}	73.73^{g}	594.58^{c}
T_2	242.50^{d}	13.82^{d}	79.55^{f}	745.84^{b}
T_3	243.83^{cd}	13.73^{e}	81.61^{e}	747.30^{b}
T_4	247.00^{bcd}	14.11^{cd}	81.66^{e}	788.31^{ab}
T_5	249.17^{bc}	14.18^{cd}	82.71^{de}	775.46^{ab}
T_6	251.28^{b}	14.28^{bcd}	83.36^{cd}	792.01^{ab}
T_7	263.70^{a}	14.98^{a}	86.08^{a}	830.58^{a}
T_8	258.33^{ab}	14.48^{bc}	84.38^{bc}	795.22^{ab}
T_9	261.08^{a}	14.73^{ab}	85.06^{ab}	827.43^{a}
LSD (0.05)	5.53	0.17	1.39	49.66
CV (%)	1.3	0.69	0.97	3.74

The results of means in columns with the same letter(s) are not significantly different at 5% level of significance; CV= coefficient of variation; LSD= least significant difference; LA=leaf area

Yield components of maize crop+

The effect of vermicompost and NPS fertilizer rates significantly ($p<0.05$) affected stand count, ear length, ear number per plant and ear number per hectare of maize crop (Table 4).

Stand count

The stand count of maize plants was determined from the final number of emerging plants from each treatment and expressed in percentage. The highest value of stand count (96.23%) was recorded from 5 t ha^{-1} VC+50 kg ha^{-1}NPS fertilizer, whereas the lowest value (82.8%) was recorded from the control treatment (Table 4). The reasons for, the increase of stand count with the application of vermicompost and NPS were attributed to the improving action of the amendments on the soil's physical properties as well as nutrient status in the soil, which enhances plant growth. Similarly, Shiferaw (2019) reported an increase in stand count with increasing amendment doses. Moreover, the combined use of vermicompost and NPS fertilizer in half of the recommended rate of both fertilizers maximize the emergency of plant population over control or sole and low application rate.

Table 4. Effect of combined vermicompost and NPS fertilizer on stand count, Ear number per plant, ear number per hectare and ear length of maize crops

	Stand Count (%)	EN/plant	EL(cm)	EN/ha
T_1	82.8^{d}	1.72^{d}	21.83^{e}	80775^{f}
T_2	92.16^{e}	2.40^{bc}	29.3^{cd}	125037de
T_3	91.83^{c}	2.28^{c}	29.42^{d}	118963^{e}
T_4	96.23^{a}	2.80a	32.12^{a}	154096^{a}
T_5	92.70^{bc}	2.43^{bc}	30.36^{c}	127767de
T_6	92.53^{bc}	2.57^{ab}	30.61^{bc}	140309^{bc}
T_7	95.50^{ab}	2.76a	31.41^{ab}	151069^{ab}
T_8	94.76^{abc}	2.63^{ab}	31.06^{bc}	141566^{bc}
T_9	93.70^{abc}	2.50bc	29.16^{d}	132339^{dc}
LSD (0.05)	2.93	0.17	0.76	10910
CV (%)	1.85	4.01	1.50	4.61

The results of means in columns with the same letters are not significantly different at 5% level of significance; CV= Coefficient of Variation; LSD= Least Significant Difference; EN/P=ear number per plant; EN/H=ear number per hectare; EL=ear length

Ear Length

Ear length substantially contributes to the grain yield of maize by influencing both numbers of grains cob and grain size. The highest value of ear length (32.12 cm) was recorded from 5 t ha^{-1} VC+50kg ha^{-1} NPS fertilizer whereas the lowest value (21.83 cm) was recorded from the control treatment (Table 4). This showed that combined use of vermicompost and NPS fertilizer with half of the recommended rate of both fertilizers created the longest length of maize ear over control and sole use

of it. The highest value of ear length at 50% vermicompost and NPS fertilizer might be due to enough nutrients that allow the plants to accumulate more biomass with a higher capacity to convert more photosynthesis into sink resulting in longer ear per plant and attributed to good photo assimilate supply. From the report of El-Gawad and Morsy (2017), ear length was significantly affected with an application of 10 t of compost and 50 Kg Urea ha^{-1}. Raman and Suganya (2018), also in harmony with the above studies and conclude that the application of 100% RDF (135 N + 62.5 P_2O_5+50 K kg ha^{-1}) with Press mud compost at a rate of 5 t ha^{-1} resulted in the highest cob length.

Ear Number per Plant

The highest value of ear number per plant (2.8) was recorded from 5 t ha^{-1} VC+50 kg ha^{-1} NPS fertilizer, whereas the lowest value (1.72) was recorded from the control treatment (Table 4). The increased number of ears per plant at 5 t ha^{-1} VC+50 kg ha^{-1} NPS fertilizer might be due to increased uptakes of major crop nutrients. Similarly, Tolera *et al*., (2017) reported that the number of cobs was significantly higher with the application of recommended NPK (225:50:50 kg ha^{-1}) with 5t FYM ha^{-1}.

Ear Number per hectare

The highest value of ear number per hectare (154,095) was recorded from 5 t ha^{-1} VC+50 kg ha^{-1}NPS fertilizer. Whereas, the lowest values (80,775) were recorded from the control treatment (Table 4). The increase in the number of ears per hectare as vermicompost and NPS fertilizer levels increased might be attributed to better uptake of nutrients and increased translocation of photosynthetic products from source to sink.

Thousand-grain weight, grain yield and biomass yield

Thousand-grain weight

Combined application of vermicompost and NPS fertilizers significantly ($p<0.05$) affected thousand-grain weight. The thousand-grain weight is a parameter contributing to the economic yield of maize and directly relates to the yield of the crop. The highest value of thousand-grain weight (331.16 g) was recorded from the plot treated with 5 t ha^{-1} VC+ 50 kg ha^{-1} NPS fertilizer while the lowest weight (290.75 g) was recorded from the control plot (Table 5). The increase in thousand-grain weight might be due to the synergistic effects of combined fertilizers for better growth, grain filling of maize crop and positive interaction of nutrients in the vermicompost and NPS fertilizers. Admas *et al*. (2015) also reported that the combined application of compost, Nitrogen and Sulfur fertilizers affected thousand-grain weights significantly.

Grain yield

The effect of vermicompost and NPS fertilizer rates significantly ($p<0.05$) affected the grain yield of maize crops. Accordingly, the highest grain yield (7.36 t ha^{-1}) was recorded from 5 t ha^{-1} VC +50 kg ha^{-1}NPS fertilizer and followed by that (7.31 t ha^{-1}) was recorded from 10 t ha^{-1} VC+100 kg ha^{-1} NPS fertilizer, while the lowest grain yield (2.94 t ha^{-1}) was recorded from control plot or treatment (Table 5). The sole application of recommended NPS fertilizer increased maize yield by 52.27% over the control treatment whereas the sole application of a full dose of vermicompost increased maize yield by 55.72% over the control treatment. This showed that organic fertilizer might have been more advantageous than inorganic fertilizer in maximizing productivity if properly used. Furthermore, the combined use of vermicompost and NPS fertilizer by the rating of half of the recommended rate of both fertilizers increased maize yield by 60.05% over the control treatment. This indicated that the combined use of organic and inorganic fertilizers is more valuable than the sole use of fertilizers. The highest grain yield with the combined application of vermicompost and NPS fertilizer might be attributed to the improving action of amendments on the soil's physicochemical properties and nutrient status in the soil, which enhances plant growth. Moreover, an increase in essential nutrients and organic matter due to the combined application of vermicompost and NPS fertilizer promotes microbial population, which ultimately enhances plant growth and production on a sustainable basis. This could be confirmed by significant and positive correlation (r = 0.92**, 0.91**, 0.82**, 0.74**, 0.88**) of grain yield of wheat with pht, TN, OC and Available P, respectively (Table 6). This finding was supported by Sanjiv (2014) who reported that the maximum grain yield of maize was recorded when 100% of NPK was applied with farmyard manure of 10 t ha^{-1}.

Table 5. The effect of vermicompost and NPS fertilizer on 1000-grain weight, grain Yield and biomass yield of maize crop

	1000-grain weight(g)	Grain yield (t ha^{-1})	Biomass yield(t ha^{-1})
T_1	290.75^{f}	2.94^{d}	4.83^{f}
T_2	312.16^{d}	6.16^{c}	11.54^{e}
T_3	314.4^{cd}	6.64^{bc}	12.41^{d}
T_4	331.16^{a}	7.36^{a}	14.51^{a}
T_5	316.5^{c}	6.26^{c}	12.71^{cd}
T_6	303.16^{e}	6.94^{ab}	13.20^{c}
T_7	322.0^{b}	7.31^{a}	13.77^{b}
T_8	313.9^{cd}	7.11^{ab}	13.81^{b}
T_9	302.86^{e}	6.79^{abc}	12.49^{d}
LSD (0.05)	0.89	0.71	0.55
CV (%)	0.52	5.08	2.5

The results of means in columns with the same letters are not significantly different at a 5% level of significance; CV= Coefficient of Variation; LSD= Least Significant Difference, g=gram, t ha^{-1}=ton per hectare

Biomass Yield

The biomass yield of maize represents the total amount of above-ground biomass accumulated by the plant. Combined application of vermicompost and NPS fertilizer is highly significant ($p<0.05$) on biomass yield. The highest value (14.51 t ha^{-1}) was recorded from the plot treated by 5 t ha^{-1} VC+50 kg ha^{-1} NPS fertilizer while the lowest (4.83 t ha^{-1}) in the control plot (Table 5). This highest value in total above-ground dry biomass over the control and organic or inorganic fertilizer alone might be due to the good response of maize crops to synergistic effects of vermicompost and NPS fertilizers which are well-recognized for the vegetative growth of plants. In agreement with this finding Kibunja *et al.* (2010) reported that the total dry matter of maize was highest from treatment combinations of inorganic and organic fertilizers than control, organic and chemical fertilizers alone.

Table 6. Simple correlation among the selected parameters

Variables	TN	OC	pH	av. P	BD	CEC	Pht	Y
TN	1.000	0.95**	0.84**	0.92**	-0.67**	0.96**	0.88**	0.82**
OC		1.00	0.93**	0.92**	-0.67**	0.91**	0.79**	0.74**
pH			1.00	0.88**	-0.70**	0.78**	0.77**	0.69**
av. P				1.00	-0.78**	0.89**	0.87**	0.83**
BD					1.00	-0.50**	-0.69**	-0.53**
CEC						1.00	0.80**	0.79**
Pht							1.00	0.92**
Y								1.00

***= significant at 0.01, TN= total nitrogen; OC= organic carbon; av. P= available phosphorus, BD=bulk density; CEC= cation exchange capacity; Pht= Plant height; Y= yield*

CONCLUSION

The results of this study revealed that the current scenarios of maize production in Toke Kutaye district call for appropriate ways of adding nutrients to the soil to obtain optimum maize productivity. In response to this, the combined application of different rates of vermicompost and NPS fertilizer to soil significantly affected most parameters used for this investigation such as plant height, leaf number, leaf length, leaf area, stand count, ear length, and several ears per plant, thousand-grain weight, total above-ground dry biomass and grain yield of maize. Moreover, the combined form of NPS blended fertilizer and vermicompost was applied and the result revealed that the sole application of recommended NPS fertilizer and vermicompost increased maize yield by 52.27 and 55.72% over control treatments, respectively. Besides this, the combined use of vermicompost and NPS fertilizer by the rating of half of the recommended rate of both fertilizers increased maize yield by 60.05% over the control treatment. This indicates that the best option for soil fertility management is integrated soil fertility management that involves the combined use of vermicompost and NPS fertilizers as nutrient sources than the strategy of using organic or inorganic amendments alone.

Then, it could be concluded that the use of blended NPS fertilizer at 50 kg $ha^{-1}$with supplemental vermicompost at 5 t ha^{-1} to Jibat variety is the realistic approach to address the problem of low productivity of maize in the study area and other similar agroecology. Based on the findings and conclusions of this study it can be recommended that farmers in the study area should, therefore, be advised to use this variety and combined use of vermicompost and NPS fertilizer at a rate of 5 t ha^{-1} VC +50 kg ha^{-1} NPS for sustainable maize crop production tentatively. Nevertheless, further studies are needed to recommend agronomical optimum and to measure the long-term effects of the integrated soil fertility management techniques in more seasons, soil types and crop varieties before giving a conclusive recommendation.

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Research Article

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Effect of cultivation method on yield, yield attributes and economics attributes of Chickpea (*Cicer arietinum* L.*)* the semi – arid Condition of Kandahar Afghanistan

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ABSTRACT
An experiment was conducted at the Agronomy farm, Afghanistan National Agricultural Science and Technology University, during the period from 2 March to 12 June 2020 to study the effect of two types of cultivation methods such as raised bed and flatbed on the yield, yield attributes and economics attributes of chickpea. The experiment was laid out in a Split Plot design with three replications. All the nutrients were applied as basal on land preparation operation. Seeds were sown manually @ 30 kg ha^{-1} for a flatbed as well as @ 45cm x 10 cm spacing for a raised bed. Observations were recorded for various growth parameters and yield attributes at 30 DAS, 60 DAS and harvest. Statistical analysis of data was done online through OPSTAT software. Raised bed cultivation method significantly enhanced the growth parameters of chickpea *viz.,* plant height (4.44 cm, 8.40 cm and 25.45 cm at 30 DAS, 60 DAS and harvest), dry matter plant^{-1} (3.12 g, 5.26 g and 15.50 g at 30 DAS, 60 DAS and at harvest. Yield attributes *viz.,* number of pod plant^{-1} (20.15), number of grain pod^{-1} (1.38), and 1,000 grain weight (207.44 g) showed remarkable improvement with raised bed cultivation method Yield of chickpea *viz.,* grain yield (1.21 t ha^{-1}), Stover yield (1.33 t ha^{-1}) biological yield (3.44 t ha^{-1}) and harvest index (27.44 t ha^{-1}) were recorded significantly higher with raised bed cultivation method. Similarly, significantly higher economics attributes *viz.,* Cost of cultivation (26,989 AFN ha^{-1}), gross returns (104,795AFN ha^{-1}), net returns (76,854 AFN ha^{-1}), and benefit cost ratio (2.78), recorded with raised bed cultivation method.
Keywords: Chickpea; yield and cultivation method

INTRODUCTION

Pulses occupy a unique position in every known system of farming all over the world. Among the pulse crops chickpea (*Cicer arietinum* L.) is a major pulse crop grown in Afghanistan for food and also used as a feed for animals. It is predominantly grown as irrigated and rain-fed in some parts of the country. Chickpea is mostly consumed in the form of processed whole seeds (boiled, roasted, parched, fried, steamed, sprouted, etc.). Chickpea is a good source of protein (18-22%), carbohydrate (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron) and vitamins (Choudhary, 2014). Chickpea is not only a source of dietary protein but also helps in the maintenance of soil fertility due to their nitrogen-fixing capability. Despite its importance as a pulse and forage crop, the yield of chickpeas is low in Afghanistan compared to other countries of the world. Amongst the agronomic practices, land configurations and proper spacing are of great importance (Reddy et al., 2003). Several workers have reported a positive response in seed yield of chickpeas to cultivation methods under protective the semi-arid condition. So, there is a need to adopt suitable management practices like a proper cultivation method for ensuring yield increment in chickpeas at Madhya Pradesh. Therefore, the study was conducted to evaluate the different sowing methods on seed yield in chickpea cultivation method is one of the important agronomic practices which greatly affects the yield and profit of many crops including chickpea. It is, therefore, necessary to evaluate the need for judicious use of cultivation methods. The current research was conducted to find out the best cultivation method for chickpea for obtaining higher agronomic characteristics and yield in the Kandahar province situation.

MATERIALS AND METHODS

Experimental Site

The present investigation entitled “Effect of cultivation method on yield, yield attributes and economics attributes of chickpea. An experiment was conducted at the Agronomy farm, Afghanistan National Agricultural Science and Technology University, during the period from 2 March to 12 June 2020, Geographically, Kandahar is situated in southern part of Afghanistan, with low-latitude semi-arid hot climate south of Afghanistan between latitude ranging from 31^0 30' north and longitude from 65^0 50' east’s and is located on an elevation of about 1010 meters above mean sea level.

Climate and soil

Kandahar has a subtropical steppe/low-latitude semi-arid hot climate. According to the Hold ridge life zones system of bioclimatic classification, Kandahar is situated in or near the warm temperate desert scrub biome. The annual mean temperature is 18.5 degrees Celsius. The average monthly temperature in Kandahar is 26.8 °C. The total annual average precipitation is 190.6 mm which is equivalent to 190.6 liters/m². On average there are 3464 sunshine hours per year. The average sunshine hours of the region ranged from 6:39 per day during February to 12:14 per day during August month. The mean relative humidity varies from 23% in June to 59% in February (http://www.kandahar.climatemps.com). During the crop growth period, the maximum temperature was 32 °C in (7-13 of May) and the minimum temperature was 0 °C from (1-7 of Jan). Moreover, the maximum relative humidity was 60.8% during 23-29 of January and the minimum relative humidity was 15.3% in (7-13 of May). The crop received total 49.8 mm of water from rainfall in five rainy days during crop growth period. The soil was having a texture of sandy clay loam. Organic matter of soil (0.69%) and PH (8.3) and available nitrogen (81.1 Kg/ ha), low in available phosphorus (8.97 kg/ ha) and available potassium (179.6 kg /ha. First irrigation was given at 18 days after sowing the four additional irrigations were given to the fulfillment of crop with 15 days interval.

Experimental design and treatment

The experiment was laid out with two types of cultivation methods (Raised bed and flatbed) in Randomized Block Design (RBD). There were 8 treatments and each treatment was replicated 3 times. The plot size was 16 m^2 (4.00 m×4.00 m), total No. of plots (24) and a Variety of Kabuli chickpea. The blocks and unit plots were separated by 0.75 m and 0.5 m. Nitrogen, phosphorus and potassium were uniformly applied @ 35, 60 and 30 kg ha^{-1} in all plots as basal with the last land preparation operation in the form of Urea and potassium sulphate respectively.

RESULTS AND DISCUSSION

Growth parameters

Data about the growth parameters of chickpea under the Cultivation method are over control at every stage of crop growth. At 30, 60 DAS and at harvest, the best method of cultivation was raised bed recorded significantly greater plant height (25.45 cm) compared to a flat bed. These results agree with the findings of K S Bhargav et al. (2018). The Dry matter per plant was maximum (15.50gr) when raised bed method which was significantly These results conform with the findings of Shashikumar et al. (2013) and S. K. Roy1 et al. (1995).

Data about yield and yield attributes of chickpea as influenced by cultivation method are indicated in (Table 2). The number of pods per plant of chickpea improved positively due to the method of cultivation. The use of raised bed cultivation method resulted in the production of a maximum number of pods per plant (20.15) of chickpea. The raised bed remained statistically superior to the flatbed respectively. This increase in the number of pods per plant with the cultivation method has resulted from more pronounced growth of the plant which in turn had increased the number of pods per plant. Bhargav, K. S., et al. (2018) and Basir, A. et al. (2008) noticed that the cultivation method at higher levels resulted in increased pod per plant.

Table 1. Effect of cultivation method on Plant height and Dry matter of chickpea in Kandahar province of Afghanistan.

	Plant height			Dry matter		
Cultivation method	**30 DAS**	**60 DAS**	**at harvest**	**30 DAS**	**60 DAS**	**at harvest**
Raised bed	4.44	8.40	25.45	3.12	5.26	15.50
Flatbed	3.83	7.80	24.82	2.75	5.07	14.86
(S E m±)	0.09	0.09	0.08	0.06	0.02	0.09
CD (P=0.05)	0.59	0.61	0.54	0.40	0.19	0.64

The number of grains per pod increased positively due to different cultivation methods in chickpea. During the study of investigation, it was observed that the use of raised bed produced the highest number of grains per pod (1.38) which was statistically on par with a flat bed. Treatment having raised bed had significantly more grain per pod. These results are further supported by the findings of Hemat, M et al. (2017) and Islam et al. (2013).

That cultivation method at higher levels resulted in increased crop growth, a particularly positive impact was noted on branching, pods, seeds and increased seed yield. Results of the present study indicated that the 1000-grain weight of chickpea was considerably affected due by the cultivation method. The maximum thousand-grain weight of chickpea (207.44 g) was recorded from the cultivation method of the raised bed. But it remained statistically at par with the method of the flatbed. Also, Tripathi, L. K. and Thomas, T (2013) observed in Iran, that grain yield, the number of seeds pod per plant and 1000 seed weight of chickpea were increased by cultivation method, similarly, Basir et al. (2008) were also recorded significantly maximum 1000 grain weight for raised bed method. The grain yield of chickpea improves remarkably due to different cultivation methods. The cultivation method of the raised bed resulted in the highest grain yield (1.21 t /ha-1) of chickpea. This treatment was significantly better but was at par with the flatbed method. Similar observations were also noted by Meena et al. (2010), Singh, V et al. (2017) and Singh, D et al. (2020), who reported that there was a significant increase in the seed yield of chickpea. The best cultivation method of raised bed produced the highest straw yield (1.33 t ha-1) of chickpea but it was statistically similar to flatbed. This may be due to the adequate supply of cultivation methods that played a vital role in physiological and developmental processes in plant life and the favourable

effect of these important nutrients might have accelerated the growth processes that as result increased the straw yield of the crop. These findings conform with the results of Kumar, P et al. (2017) and Roy, S. K. et al. (1995), who stated that the method increased dry matter production at various growth stages. The maximum biological yield (3.44 t ha-1) of chickpea was noted from raised bed method, but it was statistically similar with a flat bed. Similar results were also obtained by Bhargav, K. S et al. (2018) and Hemat et al. (2017), who revealed that raised bed method increased the growth and yield parameters. The highest value of harvest index (27.44) was recorded raised bed method which was followed by flatbed. However, the harvest index was statistically identical under all cultivation methods. The harvest index determines the amount of photosynthesis being translocated to economically important parts of the plant and the productive efficiency of the crop is determined by the extent to which assimilates are accumulated in the desirable parts of the plant (Ghapari et al 2017). Thus, the physiological efficiency of a crop to partition the available photosynthesis between its seed and other seed parts is reflected in its harvest index.

Gross returns enhanced remarkably due to the cultivation method of chickpea. The maximum gross returns (104795 AFN) of chickpea were recorded with the cultivation method of the raised bed. Similar results were also obtained by Bhargav, K. S et al. (2018) and Hemat et al. (2017), who revealed that the raises bed method increased the Gross returns. Gross returns (AFN ha^{-1}) = Economic yield × market price of produce. For obtaining the net returns (AFN ha-1), the cost of cultivation was reduced from the gross returns of each plot. Net returns followed almost the same trend as gross returns and were positively influenced due to different sowing methods. The highest net returns (76854AFN) of chickpea were obtained from the cultivation method of raised bed, this had a significant correlation (Ghapari et al 2017). Net returns (AFN ha^{-1}) = Gross returns – the cost of cultivation. For the calculation of benefit-cost ratio, the gross return was divided by the cost of cultivation. The value obtained was considered as benefit cost ratio. Benefit: cost ratio improved markedly due to various sowing methods. The highest benefit: cost ratio (2.78) of chickpea was recorded with the cultivation method of raised bed this had significant These findings conform with the results of Kumar, P et al. (2017) and Roy, S. K. et al. (1995), who stated that method increased benefit: cost ratio.

Table 2. Effect of cultivation method on yield and yield attributes of chickpea in Kandahar province of Afghanistan.

Treatment	**Pod Plant -1**	**Grain pod-1**	**Test Weight** (gm.)	**Grain** yield **(t ha-1)**	**Straw yield (t ha-1)**	**Biological yield (t ha-1)**	**Harvest index**
Cultivation method							
Raised bed	20.15	1.38	207.44	1.21	1.33	3.44	27.44
Flatbed	19.72	1.16	206.83	1.06	1.16	2.83	26.83
SE m ±	0.06	0.02	0.07	0.01	0.02	0.09	0.09
CD(P=0.05)	0.43	0.16	0.51	0.11	0.16	0.59	0.59

CONCLUSION

It was concluded from the study that crop planted on a raised bed with proper production technology gives good yield as well as economically feasible as compared to other methods of sowing chickpea. Thus, the overall performance of chickpea was superior in furrow irrigated raised bed (FIRB) over another planting system.

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Research Article

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Special Horticultural Practices for Early Induction of Flowering in Mango (*Mangifera indica* L.) cv. Ratna

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ABSTRACT
The investigation was conducted at the College of Horticulture, Dapoli, Dist. Ratnagiri, Maharashtra during the year 2020-21 to assess the special horticultural practices on induction of flowering in mango (*Mangifera indica* L.) cv. Ratna. The experiment was laid out in Randomized Block Design with three replications and ten treatments *viz*; girdling on the first fortnight of October (T_1), girdling on the first fortnight of November (T_2), girdling on the first fortnight of October and November (T_3), girdling on first fortnight of October and tip pruning (T_4), girdling on the first fortnight of November and tip pruning (T_5), girdling on the first fortnight of October and November and tip pruning (T_6), tip pruning (T_7), removal of new shoots below old shoot (T_8), smudging (T_9) and control (T_{10}). Removal of new shoots (T_7) resulted in early panicle emergence as compared to control. Treatment girdling on the first fortnight of November and tip pruning (T_5) exhibited the highest flowering intensity and hermaphrodite flower per panicle. It also maximum fruit set and fruit retention per panicle.
Keywords: Ratna, tip pruning, girdling, flowering, fruit set.

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the oldest and most popular fruits having the adorable flavour and taste of the tropical world. It belongs to the genus *Mangifera* and the family Anacardiaceae. It originated from the Indo-Burma region from the genus *Mangifera* almost all the commercial cultivars of mango are included in single species *Mangifera indica* in India. It is the most important tropical fruit in the world. Mango is called the "King of the fruits". It has been variously called *Amra, Atisourabha, Chuta, Sahakara, and Rasala,* in ancient Sanskrit literature. Among the various commercial varieties, the variety Ratna was released by DBSKKV, Dapoli (M.S.). The parentage of Ratna is Neelum and Alphonso (1981). The tree is semi-dwarf in growth habit. The fruits are large ovate (400-500g) with firm and fibreless deep orange colour pulp. It is regular in bearing. It is excellent for processing as well as table purpose. Girdling is the removal of the bark in a circular manner of either branch or trunk of woody plants. Girdling stops the basipetal movement of assimilates through the phloem which results in the accumulation of carbohydrates above the girdle which ultimately helps for induction of early and assured flowering. Urban *et al*. reported that girdling is one of the ways to improve the earliness and intensity of flowering in mango. The demand for this variety is increasing day by day owing to good keeping quality and spongy tissue-free fruits. The induction of early flowering results in the early maturity of fruits. Such fruits earn greater rates in the market as compared to late-maturing fruits. The weather during the initiation of flowering in October and November play important role in the induction of flowering at the appropriate time. It is often noticed that climatic fluctuations in October-November lead to the production of vegetative flush instead of flowering flush. This new flush requires another 80-100 days to mature as a result, flowering is considerably delayed. Late flowering leads to delayed fruit development and harvesting. The late-harvested fruits fetch low market rates. It is often noticed that many of these new shoots do not produce flowers and hence the flowering is sparse which produces poor yield (Soudagar *et al*., 2018). The young flushes are cut back up to matured wood; the resulting flush can be a floral one. It not only causes a uniform flush of growth throughout the canopy but also removes growth and flower-inhibiting factors in the stem derived from the previous season's flowering and fruiting panicles. Shoot pruning reduce the auxin synthesis at the apex of the branches, directing the transport of assimilates and cytokinin's to the axillary buds of branches under flowering condition, inducing the formation of axillary inflorescences (Srivastava, 2002). Smudging is an ancient method of inducing mango to flower. It is practised in certain parts of the

Philippines to obtain early flowering of 'Carabao' and 'Pico' mango. Ethylene has been identified as the active agent responsible for flowering during smudging (Dutcher, 1972).

MATERIALS AND METHODS

The investigation was conducted on 30 years old mango trees (cv. Ratna) at the college of horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.) India, Pin- 415712 located between 17°45' N latitude and 73°12' E longitude on West coast of Maharashtra. It has an altitude of 240 m from the MSL. The experiment laid out in randomized block design with three replications and ten treatments *viz*., girdling on first fortnight of October (T_1), girdling on first fortnight of November (T_2), girdling on the first fortnight of October and November (T_3), girdling on first fortnight of October and tip pruning (T_4), girdling on the first fortnight of November and tip pruning (T_5), girdling on the first fortnight of October and November and tip pruning (T_6), tip pruning (T_7), removal of new shoots below old shoot (T_8), smudging (T_9) and control (T_{10}). Each treatment was given two trees. The girdling was done on tertiary branches of the experimental tree by giving a circular deep cut with help of a sharp knife as per treatments. A total of 50 branches were girdled per experimental plant. On these plants, vegetative shoots emerged in November of the total new shoots. 200 shoots per experimental plant were removed at the point of emergence of mature shoots. The smudging was done in December. During smudging, the colour of newly emerged shoots was light green. Smudging was done early in the morning. On the previous day, materials like rice bran, and dry residues of the plant were collected at the base of the plant canopy. Then next day early in the morning smudging was done for about 2 hours. The entire process of smudging was performed four times at four days intervals. The data on the number of days for induction of flowering, flowering intensity (%), length of panicle (cm), the width of panicle (cm), rachis per panicle, hermaphrodite flowers percentage, fruit set (%) and fruit retention (%), number of days required for flowering to harvesting, yield was recorded. The data were analyzed by using statistical methods suggested by Panse and Sukhatme (1995)

RESULTS AND DISCUSSION

The data on the effect of girdling, tip pruning and smudging on induction of flowering presented in Table 1 indicates that they significantly influenced the flowering parameters in mango (cv. Ratna).

Days required for panicle emergence:

The early flowering (40.83 days) was observed in tip pruning (T_7) which was significantly superior over the control (131.33 days). Shoot pruning reduces the auxin synthesis at the apex of the branches, directing the transport of assimilates and cytokinins to the axillary buds of branches creating favourable conditions for flowering (Taiz and Zeiger, 2012). Gopu *et al*. (2014) found that minimum days (169 days) were required in the pruned tree as compared to the control (198 days) and showed uniform flowering per panicle in mango cv. Alphonso.

Flowering intensity:

The maximum flowering intensity (62.27%) was observed in girdling on the first fortnight of November and tip pruning (T_5) which was significantly superior over all other treatments. The minimum flowering intensity (26.67 %) was recorded in the control. Warning *et al*. (2019) recorded that maximum flowering intensity was observed by girdling in the first fortnight of September and removal of new shoots (65.67 %) as compared to control T_8 (27.33 %) in mango cv. Alphonso. Girdling is one of the ways to improve the earliness and intensity of flowering in mango cv. Cogshall (Urban *et al*., 2009). A higher percentage of flowering due to pruning treatments was mainly attributed due to the availability of photosynthetic solar radiation to the leaves which enhanced flowering (Lal and Mishra, 2007).

Panicle length (cm), Panicle width (cm) and No. of rachis per panicle:

The longest panicle (30.20 cm) was noticed in treatment girdling on the first fortnight of November and tip pruning (T_5) which was at par with T_8 (29.20 cm) and T_6 (28.83 cm). The shortest panicle (24.13 cm) was found in the treatment girdling on the first fortnight of November (T_2). The maximum width of the panicle (24.63 cm) was observed in treatment girdling on the first fortnight of November and removal of new shoots (T_5) and it was at par with T_3 (23.67cm) and T_4 (22.97 cm). The minimum panicle width (17.27cm) was found in the control (T_{10}). The highest number of rachises per panicle (31.57) was found in the treatment removal of new shoots below old shoot (T_8) which was at par with T_5 (30.63), T_4 (29.77), T_6 (29.77), T_3 (28.97). The lowest number of rachises per panicle (25.30) was recorded in girdling on the first fortnight of October (T_1) (Table 1). There was an increase in the length and width of the panicle as well as several rachides per panicle by girdling on the first fortnight of November and tip pruning (removal of new shoots). It may be due to the availability of more sugars and auxins in branches. Nachare (2020) observed the longest length of panicle in girdling on the first fortnight of September (31.37cm) in mango cv. Ratna. Shoot pruning was significantly effective in increasing the length and width of the panicle. Removal of new shoots leads to the formation of longer panicle lengths due to gross changes in endogenous hormonal levels (Singh *et al*., 2010). Shoot pruning reduces the auxin synthesis at the apex of the branches, directing the transport of assimilates and cytokinin's to the axillary buds of branches, creating favourable conditions for flowering (Taiz and Zeiger, 2012).

Hermaphrodite flower (%), Fruit set and fruit retention (%):

The data on hermaphrodite flower percentage, fruit set, fruit retention, days required from flowering to harvesting and yield are presented in Table 2. Treatment T_5 resulted in maximum hermaphrodite flowers (15.01 %), fruit set (8.53 %) with 0.95 per cent fruit retention and which was significantly superior over control. The highest number of hermaphrodite flowers (%) due to the removal of new shoots was also reported in the earlier studies in mango cv. Alphonso by Gopu *et al*., (2014). The control (untreated) resulted in minimum hermaphrodite flowers (10.98%), minimum fruit set (5.03%) and fruit retention (0.50%). Warang *et al*., (2019) reported that girdling on the first fortnight of the September and removal of new shoots produced highest fruit set per panicle in mango cv. Alphonso. Nachare (2020) also found same results in mango cv. Ratna.

Table 1. Effect of girdling tip pruning and smudging on number of days required for flower induction, flowering intensity and hermaphrodite flower of mango cv. Ratna.

Treatments	Days required for panicle emergence	Flowering intensity (%)	Panicle length (cm)	Panicle width (cm)	No rachis per panicle
T_1	91.33	38.33	26.30	20.87	25.30
T_2	76.33	43.33	24.13	19.97	28.33
T_3	94.17	41.67	25.10	23.67	28.97
T_4	64.83	59.17	25.20	22.97	29.77
T_5	44.67	62.27	30.20	24.63	30.63
T_6	77.33	60.83	28.83	21.57	29.77
T_7	40.83	52.50	27.67	19.67	26.73
T_8	42.33	42.50	29.20	19.97	31.57
T_9	65.50	32.50	27.47	20.40	27.67
T_{10}	131.33	26.67	25.57	17.27	26.20
CD at 5%	6.63	6.70	1.92	2.73	2.72

Table 2. Effect of girdling tip pruning and smudging on fruit set and fruit retention per panicle of mango cv. Ratna.

Treatments	Hermaphrodite flower (%)	Fruit set	Fruit retention (%)	Days required from flowering to harvesting	Yield (no of fruits /tree)	Yield (kg/ tree)
T_1	12.43	6.30	0.64	150.33	106.67	43.08
T_2	12.17	6.00	0.59	149.67	102.50	41.81
T_3	12.07	5.73	0.57	156.33	101.50	41.48
T_4	14.50	7.30	0.77	147.50	116.33	49.45
T_5	15.01	8.53	0.95	141.07	145.00	61.58
T_6	14.75	8.23	0.87	155.73	134.67	58.10
T_7	13.30	6.70	0.72	134.87	126.33	55.23
T_8	12.10	5.97	0.57	141.67	108.50	48.45
T_9	11.31	5.42	0.55	149.33	100.00	40.52
T_{10}	10.98	5.03	0.50	165.00	88.33	29.47
CD at 5%	1.50	0.33	0.06	7.16	7.89	3.30

Days required from flowering to harvest:

The minimum days required for flowering to harvest were recorded in treatment T_7 -tip pruning (141.07 days) which was significantly superior among all other treatments. Tip pruning facilitated early flowering and harvesting in mango cv. Ratna. It increases photosynthate translocation to flower buds which result in earlier fruit set which lead to early harvest than control (Lal *et al*., 2000). Soudagar *et al*. (2018) exhibited that the minimum number of days required for harvesting in tip pruning by retaining 2 leaves in mango cv. Alphonso. Similar results were observed by Warang *et al*. (2019) in mango cv. Alphonso and Nachare (2020) in mango cv. Ratna.

Yield:

The treatment T_5 was maximum fruit yield 145 (fruits per tree) or 61.58 kg/ tree. Treatment T_7 were required minimum days (134.67 days) from flowering to harvesting which was superior over all other treatments. Girdling can improve carbohydrate availability to fruits and as a consequent lead to an increased fruit set percentage with decreased bud drop due to branch girdling it also leads to increase maximum number of fruit per shoots and maximum fruit weight which help to increased fruit yield kg per plant and fruit yield kg per hectare (Goren *et al*., 2003). Shinde *et al*. (2014) noticed the highest number of fruits per plant in T_1 (ringing during the first fortnight of May) in cv. Alphonso. Ghadage *et al*. (2017) girdling on 15th July produced a

significantly maximum yield (94.20kg/plant) in mango cv. Alphonso. This may be due to girdling which improved carbohydrate availability to earlier development of fruit and even the removal of new shoots may have stopped the translocation of food to new vegetative growth. The present findings are similar lines with Warnag *et al*., (2019) in mango cv. Alphonso and Nachare (2020) in mango cv. Ratna.

CONCLUSION

The trial conducted those special horticultural practices viz. girdling, removal of new shoots (tip pruning) and smudging in mango cv. Ratna was beneficial for early induction of flowering and early harvesting. Among all treatments, T_7 (removal of new shoots) was best for early induction of flowering and early harvesting. Treatment T_5 (girdling on the first fortnight of November and tip pruning) was best for the highest hermaphrodite flowers, maximum fruit set and retention and also contributed to the highest yield with greater appreciation concerning rate in the market. Girdling, removal of new shoots and smudging did not influence the physiochemical composition of mango.

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Research Article

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Impact of Land cover Dynamics on Ecosystem services value of Siwalik range of Madhesh Province Nepal

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ABSTRACT
The Siwalik region is the area that lies between the hills in the north and Terai in the south. It provides a wide range of services and is of particular interest from a land use land cover (LULC) change perspective as it is naturally fragile and prone to degradation. The study was conducted in Madhesh Province Siwalik to assess the LULC change over three time periods and to quantify the change in ecosystem services value (ESV) due to LULC change. Remote sensing, Google Earth Engine and Arc GIS were used to prepare the land cover map. In 2000, 2010 and 2020 total area covered by the forest was 68.46%, 65.58% and 71.17%, agriculture was 16.50%, 18.21% and 16.21% and waterbodies were 4.40%, 3.89% and 3.79% respectively. From 2000-2010 forest and waterbodies decreased by 3.87%, and 0.54% respectively whereas agriculture and other land increased by 1.7% and 2.71% respectively. Similarly, from 2010 to 2020, agriculture, water bodies, and other land decreased by 1.99%, 0.10%, and 4.48% whereas forests increased by 6.58% respectively. The overall accuracy of the map is 90%, 89% and 88% for the years 2000, 2010 and 2020. The ESV was estimated using the value transfer method, which was 28 million USD/year, 26.84 million USD/year, and 28.97 million USD/year in 2000, 2010 and 2020, which showed that the total ESV has decreased by 1.16 and increased by 2.12 million USD from 2000-2020. An elasticity indicator shows 1% of land conversion in Siwalik resulted in 0.47 % and 0.21 % changes in ESVs during the two periods, respectively. Overall findings of this study, suggest that ESV has increased in the Siwalik region of Madhesh province in the last two decades, primarily due to an increase in forest cover. This increase should be taken as an opportunity to leverage policy support and programmatic implementation to increase forest cover and reduce land conversion.
Keywords: Chure region, Elasticity, Google Earth Engine, Land use land cover change, Remote sensing.

INTRODUCTION

The Land is a crucial feature and the foundation for the survival of human beings and ecosystem services on Earth (Yoshida et al., 2010). Changes in land use and land cover (LUCC) have a profound impact on the ecosystem's core components and are indicators of changes to the world's ecology (Xu et al., 2016). Ecosystem services maintain the ecological process and function and support the living organism on the Earth. Over the past few decades, 60% of ecosystem services around the world have deteriorated (Costanza et al., 2014). Change in land cover is a dynamic and continuous process (Mondal, 2016); both natural and artificial processes can cause it. Anthropogenic activities have become a major force that dramatically reshapes the ecosystem (Randin et al., 2020). So, Continuous LULC observation of those changes is essential in monitoring overall environmental and ecosystem services (Lal & Anouncia, 2015).

The application of Remote Sensing, GIS, and Google Earth Engine (GEE) acts as an efficient tool in mapping the LULC change and Ecosystem services (ES) Value research. The method used by various researchers for the Valuation of Ecosystem Services (Sharma et al., 2019; Shrestha et al., 2019; Rai et al., 2018). So, the study used remote sensing and GEE for the LULC change and benefit transfer method for the evaluation of ES value.

Although biodiversity and ecosystem conservation have greatly improved in Nepal, there has been little progress in the concept's application. Various work has been done by the Nepal government to make the use of ecosystem services idea, for example, the inclusion of ES in the national plan and preparation of national policy on payment of ecosystem services. However, there is still a

lack of policy and planning for the conservation and management of natural resources, which has a huge negative impact on ES and forces trade-offs.

Nepal has fragile geography among them, Chure is one of the ecologically weak and disaster-prone areas (Aulestia, 2019) which makes it the fastest land cover changing place. Chure acts as the water tower for the southern region of Nepal. To convey to the people about the land use land cover change impact it is necessary to assess the value of the service the land cover provides. Hence continuous assessment of LULC and ESV is essential for the conservation and Management of the Chure region. The study provides baseline data for better land use planning and further research.

MATERIALS AND METHODS

Study area

The study was conducted in Nepal's Madhesh Province Chure (Siwalik) Physiographic region (Figure 1) as it is a region naturally ecologically fragile and prone to degradation. The region geologically belongs to the Palaeocene and the early Quaternary consists of conglomerate, sandstone, and shale (MFSC, 1988). The region comprises about 2065 Km^2 of landmass extending across 8 districts of Madhesh Province, which covers 21 % of the total landmass. The climate of Siwalik ranges from tropical to sub-tropical. The region supports the agro- productivity of the Terai region of Nepal.

Figure 1. Location Map of Siwalik range

Land use land cover Classification

Freely available time series Landsat imagery for 2000, 2010 and 2020 was used. For the year 2000 and 2010 Landsat 7 Enhanced Thematic Mapper (ETM+) and 2020 Landsat 8 Operational Land Imager images (OLI) from United State Geological Survey (USGS) was extracted. The maximum cloud cover was taken less than 30%. A geometric and radiometric correction was conducted after that three Land use land cover classes were classified based on the requirement. The total land cover types are shown in Table 1

Table 1. Land cover classes

Land cover	Description
Agriculture (Cropland)	Lands covered with temporary crops followed by harvest period & crop Field.
Forest	Areas covered with trees forming closed or nearly closed canopies.
Waterbodies	Rivers, Lakes, ponds, and other areas with the presence of water.
Other lands	Includes all the excluded lands like bare land, bare soil, and built-up areas grassland.

A supervised approach, Random Forest classier was used for LULC classification. High-resolution images from Google Earth and Global Positing system points were collected from the Forest research and training centre for the year 2020. Training samples and a total of 20-30 % of the training sample were collected for the validation of the LULC map as shown in Table 2.

Table 2. Training and validation points for LULC classification

Year	Land Cover Classes	Training Points	Validation Points
2000	Forest	252	63
	Agriculture	319	85
	Water body	171	55
2010	Forest	261	57
	Agriculture	331	93
	Water body	177	44
2020	Forest	268	54
	Agriculture	398	90
	Water body	192	49

Estimation of Ecosystem Services Value and its Change due to LULC changes

The benefit transfer Method was used to extrapolate the ecosystem services value to the Siwalik physiographic region. The method, in the absence of site-specific valuation data, uses the current values and other information from the original study to estimate ESVs of additional similar locations. The method is used because it is cost-effective (Oh, 2014). The research use Ecosystem Services Value (Rai et al., 2017) for LULC types. The paper contains the site-specific value of the Chure region. All value coefficients were changed to 2000 USD per hectare per year using the inflation factor to account for the time effect of value to simplify the estimating procedure of ESV changes. The formula used to calculate the Ecosystem services value is given in Equation 1:

$ESV = \sum (Ak \times VCk)$ …. (Costanza et al., 1997) ……. Equation 1

Where → ESV is the estimated ecosystem services value,

→ Ak = area (ha),

→VCk = the value coefficient (USD/ha/year) for the land use category "k"

Elasticity of ESV changes in the response to LULC changes

Elasticity, which is defined by (Song & Deng, 2017) was applied to examine the relationship between LULC and ESVs. The major reason for the use of elasticity is to calculate the percentage change in ESV to the percentage change in LULC. The given formula was used to calculate the elasticity are shown in Equation 2:

$$EEL = \frac{\frac{Eend-Estart}{Estart} * \frac{1}{T} * 100\%}{LCP} \quad \text{..... Equation 1}$$

$$\text{LCP} = \frac{\sum_{n=1}^{n} \Delta LUTi}{\sum_{n=1}^{n} LUTi} * \frac{1}{T} * 100\%$$

Where,

EEL= Elasticity of changes in ESV in response to LULCC

E_{end}=ESV at the end of the research period

E_{start}=ESV at the start of the research period

LCP=Land conversion percentage

LCP can reveal both the conversion speed and degree of LUCC, ΔLUTi is the converted area of LUCC type I, LUTi is the area of LUCC type I and T denotes the year within the research period.

RESULTS AND DISCUSSION

Land Use Land Cover Change Analysis

The LULC Maps of each study period were prepared by using Landsat satellite images 7 and 8 using GEE. Four LULC classes were analysed i.e., Forest, Agriculture, Waterbodies and other land. The LULC Maps for the years 2000, 2010 and 2020 are presented in Figure 2, 3 and 4.

From 2000 to 2020, the dominant LULC types in Chure were forest followed by agricultural land, Otherland and Water bodies. In 2000, Forest (68.46%) was the major land cover class followed by agriculture (16.50%), otherland (10.59%) and water bodies (4.44%). In LULC 2010, Forest (65.58%) followed by agriculture (18.21%), otherland (13.30%) and water bodies (3.89 %) and in 2020, Forest (71.17%) followed by agriculture (16.21%), other land (8.82%) and water bodies (3.79%)

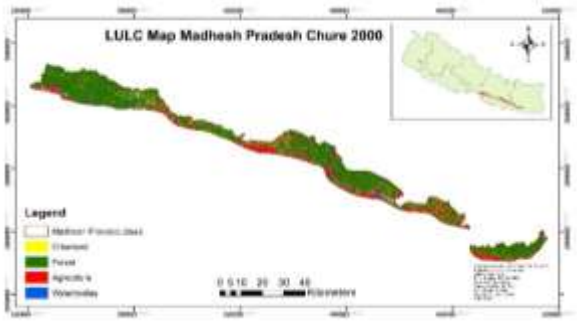

Figure 2. Land use land cover Map of 2000

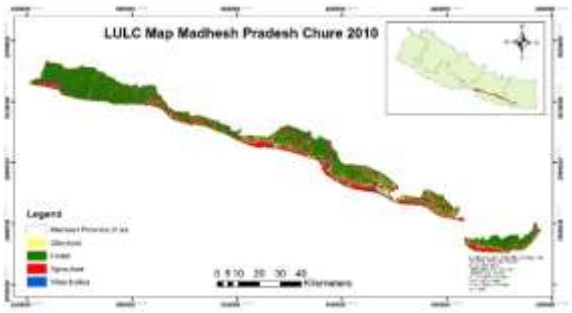

Figure 3. Land use land cover Map of 2010

Figure 4. Land use land cover Map of 2020

Land use Land Cover Area from 2000 to 2020

The result of LULC change from 2000 to 2010 indicated that there was a decrease in the forest, and waterbodies by 3.87%, and 0.54% and agriculture and other land increased by 1.7% and 2.71% respectively. Similarly, from 2010 to 2020, agriculture, waterbodies, and other land decreased by 1.99%, 0.10% and 4.48% whereas Forests increased by 6.58%. From 2000 to 2020 the area of the forest increased by 2.70% whereas agriculture, waterbodies and other land decreased by 0.28%, 0.65% and 1.76%.

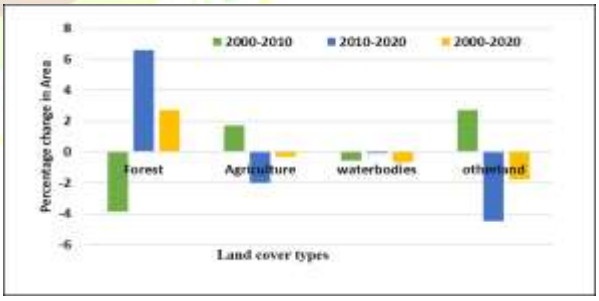

Figure 5. Land use land cover change from 2000 to 2020

Estimation of Ecosystem Services value and its changes

The total ecosystem service value of the Siwalik region was estimated at USD 28 million per year in 2000, USD 26.84 million per year in 2010 and USD 28.97 million per year in 2020. It was found that in 2020, 71 % of the land was covered by forest and delivered USD 26.39 million per year which was the highest value whereas agriculture was delivered for USD 2.57 million per year. Similarly, in 2010 forest delivered USD 23.94 million per year, i.e., 65% of the landscape was covered by forest

and agriculture delivered USD 2.89 million per year. Similarly, in 2000, forest delivered USD 25.38 million per year whereas agriculture delivered USD 2.62 million per year. Ecosystem services which were included Forest products, Biodiversity and pharmaceuticals, Hydrological services, and food production. These are the major ecosystem services provided by the cure region (Acharya et al., 2019)

Impact of LULC on spatially explicit ESVs

To understand the impact of LULC change on the total ESV and their relationship, we have calculated the elasticity of ESV in response to LULC changes. The elasticity in the repose of LULC change was calculated using Equation 2 and is presented in Figure 6. It shows the elasticity of ESV in response to LULC change was 0.47, 0.27 and 0.63 during the period 2000-2010, 2010-2020 and 2000-2020 respectively. The elasticity implies that a 1% transition of LULC would result respectively in on average 0.47%, 0.27% and 0.63% chance of total ESV during the study period. The fluctuation trend of ESV is illustrated in Figure 6. The elasticity of ESV declined from 0.47 to 0.27 during the period 2000 to 2020. The decreasing trend of ESV implies that ESV is less sensitive to LULC change during this period. The higher value of ESV during 2000-2020 indicates that the greatest change in ESV occurred during this period due to LULCC.

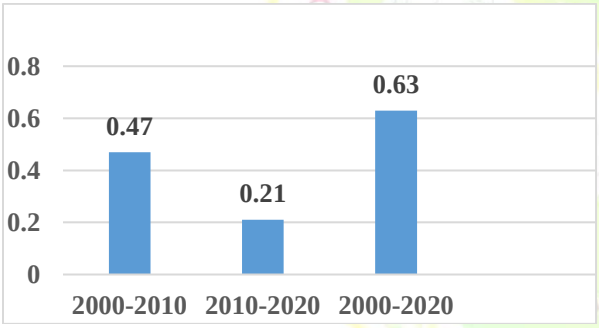

Figure 6. Elasticity of ESV in response to LULC change

For effective natural resource management, detailed LULC research is crucial(Uddin et al., 2015). A Landsat image was extracted, and a land use land cover map was prepared for the years 2000, 2010 and 2020. In this study, we use GEE to classify the LULC by using RF algorithm in the Siwalik region of Madhesh province. Cloud masking, shadow masking, Bidirectional reflectance distribution function correction, and topographic correction were used to improve the accuracy of the classification. The overall accuracies of the LULC classification in 2000, 2010 and 2020 were 88.17%, 89.69 % and 90% respectively indicating the good performance of our methods. Based on LULC we further estimated the ESVs of the chure and the relationship between ESVs in response to LULC change.

Land Use Land Cover Change

Total of four major land cover classes were included i.e., Forest, Agriculture, waterbodies, and other land. The results here presented show that in 2000 forest cover and agriculture in chure region occupied 68.46% and 16.50% of the area. Due to insufficient regional LULC literature, results agree with Bhuju, Yonzan, and Badiya (2007), who quantified that 61.2% of the eastern chure hills were covered by forests by 1992 and agriculture represented 8.5%. In 2010, the forest cover occupied 65.58% (a decrease of 3%) of the total area. Similarly, the report authored by FRA/DFRS (2014) indicates the region has experienced deforestation at a rate of -0.8% from 1995 to 2010. Likewise, Ghimire (2017) also found deforestation in the chure hills and inner terai valley from 1954 to 2015. The LULC of Nepal reports that agricultural land occupied 10.74% of the chure by 2010, while the study found 18% in the study area. In 2020, there were almost 71.17% of the total land is covered by forest. The national land cover monitoring system(NLCMS) 2019 (FRTC, 2022) showed 41.69% of land in Nepal is covered by forest, (Sharma et al., 2019) showed 44% of the land is covered by forest in TAL. The chure land use land cover has been gone through nominal change over twenty years. LULC changes are dynamic and nonlinear, which means that due to a variety of natural and artificial reasons, the transition from one land cover to another does not follow a consistent pattern throughout the year. From 2010 to 2020, there was a decrease in agriculture (1.99%) and an increased in the forest (6.58%). NLCMS showed forests increased by 1.70%, agriculture decreased by 2.10% from 2000 to 2019 (FRTC, 2022). GDP contribution from agriculture drastically decreased in 2018. There was a decrease in other lands from 2000 to 2020 which asserts with the result (Pandey 2022) shows a decrease in other lands due to conversion into forest. The finding showed the decreasing trend of waterbodies in the chure which complies with the finding (SAWTEE, 2016)due to increasing deforestation and extraction of water materials from rivers. The increase in the forest cover after 2010 might be due to Chure Terai Madhesh Conservation Programme (2010), the declaration of Chure as EPA under the Environment Protection Act (1997) on July 14 2014, and the Forest policy (2015) which might act as a boon policy for the forest in Nepal. The study showed that from 2000-2010 most of the forest was converted into other land and agriculture whereas from 2010 to 2020 most of the other land was converted into forest. In the Chure region, maximum land conversion has been found from agriculture to forest and forest to agriculture from 2000 to 2014 (Aulestia, 2019).

Valuation of Ecosystem Services and comparison between ESV coefficients

Costanza et al. (1997) have provided the global ecosystem valuation which is used by researchers since valuing the global ecosystem services. Based on LULC change, research quantified the ESV of the chure region during the period from 2000 to 2020 at a 10-year interval. The research finding identified that LULC causes a change in ecosystem services value. In each year ESV coefficient, our study envisioned decreasing

trend of ESV of 1.16 % from 2000 to 2010 and an increasing trend of 2.13% from 2010 to 2020. For the temporal comparison of changes in ESV better to include the ESV which is adjusted to the base year rather than adjusted inflation ESV for a different period (Shrestha et al., 2019). In ESV coefficient, showed an increasing trend of ESV from 2010 to 2020 due to an increase in forest cover through the agriculture area decreases by 1.99%, which implies that ESV is mostly dependent upon the forest because it provides a wide variety and high-value ecosystem services. The other studies also revealed a decrease in ESV due to a decrease in forest cover (Sharma et al., 2019).

The loss in global ecosystem services due to LULC change was about $4.3-20.2 trillion from 1997 to 2011. In the Tibetan plateau, ESV increased at the rate of 67.10× 108 between the years 1985 to 2000 however between 2000 to 2010 the ESV decreases at the rate of 49.30 × 108. In the Gandaki river basin, the ESV increased from 50.16 × 108 USD/year to 51.84 × 108 USD/year between 1990 and 2015 (Rai et al., 2018). The increase in ESV is due to enhancement in cropland, forest, waterbodies, wetland and barren land. Similarly, in the Karnali river basin, the ESV increased from 45.87 × 108 USD/year to 45.89× 108 USD/year between 2000 and 2017 (Shrestha et al., 2019). The slight increase in ESV is due to a slight increase in grassland, agriculture and barren land. However, the Koshi river basin showed a decreasing ESV from $91.60 × 108 and $89.55 × 108 between 1990 to 2010 (Zhilong et al., 2017). The loss is due to human interferences such as urbanization, deforestation and land reclamation in the Koshi river basin(Zhilong et al., 2017). Similarly, in TAL the ESV decreased from 1275 million USD to 1264 million USD between 2001 to 2016(Sharma et al., 2019. The loss is primarily due to a decrease in forest cover, and cropland in the TAL area (Sharma et al., 2019). Here, other land and water bodies derived no ecosystem services value due to a lack of ESV coefficient considering the local context. There was very less increment in ESV of Madhesh Province as compared to Gandaki and Karnali river basin because the study used limited ecosystem services of land cover forest and agriculture only and it considers the local ESV coefficient Rai (2017) rather than Xie's (2003). Research findings on the elasticity of ESV in response to LULC change showed that the change of ESV due to LULC change is elastic. The elasticity during the period 2000 to 2010 was 0.47 implies that the conversion of 1% of the land area would result in an average change of 0.47% of ESVs. It decreases because of the increase (6%) in forest cover. The elasticity from 2010 to 2020 was 0.21 which implies that the conversion of 1% of the land area would result in an average change of 0.21 % of ESVs. High elasticity indicates that even small LULC changes would have serious effects on ESV. The elasticity of KSL-China was 5.27, KSL- Nepal 4.34 and KSL-India was 1.57 between 2000 to 2015, Nepal shows the second highest 4.34 due to loss in forest cover (394.47 km2) during the 15 years (Gu et al., 2021).

CONCLUSION

In this study, the LULC study was conducted on the entire Siwalik of Madhesh Province and further quantified the change in ESV between 2000 to 2010 and 2010 to 2020. During the study period, the Madhesh province Siwalik experienced significant LULC change, forest (3.87%) and waterbodies (0.54%) decreased, whereas agriculture (1.7%) and other lands (2.71%) increased. Between 2010 to 2020, agriculture (1.99%), waterbodies (0.10%) and another land (6.58%) decreased, whereas forest (6.58%) increased. The overall finding from 2000 to 2020 shows condition of Madhesh province Chure is improving due to an increment in the forest due to the major conversion of other lands (Grassland, shrubland, built-up areas) and agriculture into the forest. Meanwhile, which also indicates that there was an abandonment of agriculture in the Madhesh province of Chure. Between 2000 and 2010, the total ESV in the study area decreased by 1.16 million USD/ year. This decrease was mainly due to a decrease in forest cover (2.88%). Between 2010 to 2020, the ESV increased by 0.9 million USD/ year due to an increase in forest cover. In the ESV coefficient based on base year, the decrease and increase of ESV in forest cover contributed most to the loss and gain of total ESV and the high elasticity. This study revealed that even small LULC changes could cause relevant high ESV changes in the Chure.

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Research Article

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Effect of cultivation method on yield, yield attributes and economics attributes of Chickpea (*Cicer arietinum* L) the semi-arid Condition of Kandahar Afghanistan

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ABSTRACT
An experiment was conducted at the Agronomy farm, Afghanistan National Agricultural Science and Technology University, during the period from 2 March to 12 June 2020 to study the effect of two types of cultivation methods such as raised bed and flatbed on the yield, yield attributes and economics attributes of chickpea. The experiment was laid out in a Split Plot design with three replications. All the nutrients were applied as basal on land preparation operation. Seeds were sown manually @ 30 kg ha^{-1} for a flatbed as well as @ 45cm x 10 cm spacing for a raised bed. Observations were recorded for various growth parameters and yield attributes at 30 DAS, 60 DAS and harvest. Statistical analysis of data was done online through OPSTAT software. Raised bed cultivation method significantly enhanced the growth parameters of chickpea *viz.,* plant height (4.44 cm, 8.40 cm and 25.45 cm at 30 DAS, 60 DAS and harvest), dry matter plant^{-1} (3.12 g, 5.26 g and 15.50 g at 30 DAS, 60 DAS and at harvest. Yield attributes *viz.,* number of pod plant^{-1} (20.15), number of grain pod^{-1} (1.38), and 1,000-grain weight (207.44 g) showed remarkable improvement with raised bed cultivation method Yield of chickpea *viz.,* grain yield (1.21 t ha^{-1}), Stover yield (1.33 t ha^{-1}) biological yield (3.44 t ha^{-1}) and harvest index (27.44 t ha^{-1}) were recorded significantly higher with raised bed cultivation method. Similarly, significantly higher economics attributes *viz.,* Cost of cultivation (26,989 AFN ha^{-1}), gross returns (104,795AFN ha^{-1}), net returns (76,854 AFN ha^{-1}), and benefit-cost ratio (2.78), recorded with raised bed cultivation method.
Keywords: Chickpea, Yield, Cultivation methods.

INTRODUCTION

Pulses occupy a unique position in every known system of farming all over the world. Among the pulse crops chickpea (*Cicer arietinum* L.) is a major pulse crop grown in Afghanistan for food and also used as a feed for animals. It is predominantly grown as irrigated and rain-fed in some parts of the country. Chickpea is mostly consumed in the form of processed whole seeds (boiled, roasted, parched, fried, steamed, sprouted, etc.). Chickpea is a good source of protein (18-22%), carbohydrate (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron) and vitamins (Choudhary, 2014). Chickpea is not only a source of dietary protein but also helps in the maintenance of soil fertility due to their nitrogen-fixing capability. Despite its importance as a pulse and forage crop, the yield of chickpeas is low in Afghanistan compared to other countries of the world. Amongst the agronomic practices, land configurations and proper spacing are of great importance (Reddy et al., 2003). Several workers have reported a positive response in the seed yield of chickpeas to cultivation methods under protective of the semi-arid condition. So, there is a need to adopt a suitable management practice like a proper cultivation method for ensuring yield increment in chickpea in Madhya Pradesh. Therefore, the study was conducted to evaluate the different sowing methods on seed yield in chickpea cultivation method is one of the important agronomic practices which greatly affects the yield and profit of many crops including chickpea. It is, therefore, necessary to evaluate the need for judicious use of cultivation methods. The current research was conducted to find out the best cultivation method for chickpea for obtaining higher agronomic characteristics and yield in the Kandahar province situation.

MATERIALS AND METHODS

Experimental Site

The present investigation entitled "Effect of cultivation method on yield, yield attributes and economics attributes of chickpea. An experiment was conducted at the Agronomy farm, Afghanistan National Agricultural Science and Technology University, during the period from 2 March to 12 June 2020, Geographically, Kandahar is situated in the southern part of Afghanistan, with low-latitude semi-arid hot climate south of Afghanistan between latitude ranging from 310 30' north

and longitude from 650 50' east's and is located on an elevation of about 1010 meters above mean sea level.

Climate and soil

Kandahar has a subtropical steppe/low-latitude semi-arid hot climate. According to the Hold ridge life zones system of bioclimatic classification, Kandahar is situated in or near the warm temperate desert scrub biome. The annual mean temperature is 18.5 degrees Celsius. The average monthly temperature in Kandahar is 26.8 °C. The total annual average precipitation is 190.6 mm which is equivalent to 190.6 liters/m². On average there are 3464 sunshine hours per year. The average sunshine hours of the region ranged from 6:39 per day during February to 12:14 per day during August month. The mean relative humidity varies from 23% in June to 59% in February (http://www.kandahar.climatemps.com). During the crop growth period, the maximum temperature was 32 °C from (7-13 of May) and the minimum temperature was 0 °C from (1-7 of Jan). Moreover, the maximum relative humidity was 60.8% during 23-29 January and the minimum relative humidity was 15.3% on (7-13 May). The crop received a total 49.8 mm of water from rainfall on five rainy days during the crop growth period. The soil was having a texture of sandy clay loam. Organic matter of soil (0.69%) and PH (8.3) and available nitrogen (81.1 Kg/ ha), low in available phosphorus (8.97 kg/ ha) and available potassium (179.6 kg /ha. First irrigation was given at 18 days after sowing the four additional irrigations were given to the fulfilment of crop with 15 days intervals.

Experimental design and treatment

The experiment was laid out with two types of cultivation methods (Raised bed and flatbed) in Randomized Block Design (RBD). There were 8 treatments and each treatment was replicated 3 times. The plot size was 16 m2 (4.00 m×4.00 m), total No. of plots (24) and a variety of Kabuli chickpea. The blocks and unit plots were separated by 0.75 m and 0.5 m. Nitrogen, phosphorus and potassium were uniformly applied @ 35, 60 and 30 kg ha-1 in all plots as basal with the last land preparation operation in the form of Urea and potassium sulphate respectively

RESULTS AND DISCUSSION

Growth parameters

Data about the growth parameters of chickpea under the Cultivation method are over control at every stage of crop gr owth. At 30, 60 DAS and at harvest, the best method of cultivation was raised bed recorded significantly greater plant height (25.45 cm) compared to a flat bed. These results agree with the findings of K S Bhargav et al. (2018). The Dry matter per plant was maximum (15.50gr) when raised bed method which was significantly These results conform with the findings of Shashikumar et al. (2013) and S. K. Roy1 et al. (1995).

Yield parameter

Data concerning yield and yield attributes of chickpea as influenced by cultivation method are indicated in (Table 2). The number of pods per plant of chickpea improved positively due to the method of cultivation. The use of raised bed cultivation method resulted in the production of a maximum number of pods per plant (20.15) of chickpea. The raised bed remained statistically superior to the flatbed respectively. This increase in the number of pods per plant with the cultivation method has resulted from more pronounced growth of the plant which in turn had increased the number of pods per plant. Bhargav, K. S., et al. (2018) and Basir, A. et al. (2008) noticed that cultivation methods at higher levels resulted in increased pod per plant. The number of grains per pod increased positively due to different cultivation methods in chickpea. During the study of investigation, it was observed that the use of raised bed produced the highest number of grains per pod (1.38) which was statistically on par with a flat bed. Treatment having raised beds had significantly more grain per pod. These results are further supported by the findings of Hemat, M et al. (2017) and Islam et al. (2013).

Table 1. Effect of cultivation method on Plant height and Dry matter of chickpea in Kandahar province of Afghanistan

	Plant height			Dry matter		
Cultivation method	30 DAS	60 DAS	at harvest	30 DAS	60 DAS	at harvest
Raised bed	4.44	8.40	5.45	3.12	5.26	15.50
Flatbed	3.83	7.80	24.82	2.75	5.07	14.86
(S E m±)	0.09	0.09	0.08	0.06	0.02	0.09
CD (P=0.05)	0.59	0.61	0.54	0.40	0.19	0.64

That cultivation method at higher levels resulted in increased crop growth, a particularly positive impact was noted on branching, pods, seeds and increased seed yield. Results of the present study indicated that the 1000-grain weight of chickpea was considerably affected due to the cultivation method. The maximum thousand-grain weight of the chickpea (207.44 g) was recorded from the cultivation method of the raised bed. But it remained statistically at par with the method of a flat bed. Also, Tripathi, L. K. and Thomas, T (2013) observed in Iran, that grain yield, the number of seeds pod per plant and 1000 seed weight of chickpea were increased by cultivation method, similarly, Basir et al. (2008) were also recorded significantly maximum 1000 grain weight for raised bed method. The grain yield of chickpea improves remarkably due to different cultivation methods. The cultivation method of the raised bed resulted in the highest grain yield (1.21 t /ha-1) of chickpeas. This treatment was significantly better. but was at par with the flatbed method. Similar observations were also noted by Meena et al. (2010), Singh, V et al. (2017) and Singh, D et al. (2020), who reported that there was a significant increase in the seed yield of chickpea. The best cultivation method of raised

bed produced the highest straw yield (1.33 t ha-1) of chickpea. but it was statistically similar to flatbed. This may be due to the adequate supply of cultivation methods that played a vital role in physiological and developmental processes in plant life and the favourable effect of these important nutrients might have accelerated the growth processes that as result increased the stra w yield of the crop. These findings conform with the results of Kumar, P et al. (2017) and Roy, S. K. et al. (1995), who stated that the method increased dry matter production at various growth stages. The maximum biological yield (3.44 t ha-1) of chickpea was noted from raised bed method, but it was statistically similar with a flat bed. Similar results were also obtained by Bhargav, K. S et al. (2018) and Hemat et al. (2017), who revealed that the raised bed method increased the growth and yield parameters. The highest value of harvest index (27.44) was recorded raised bed method which was followed by flatbed. However, the harvest index was statistically identical under all cultivation methods. The harvest index determines the amount of photosynthesis being translocated to economically important parts of the plant and the productive efficiency of the crop is determined by the extent to which assimilates are accumulated in the desirable parts of the plant (Ghapari et al 2017). Thus, the physiological efficiency of a crop to partition the available photosynthesis between its seed and other seed parts is reflected in its harvest index.

Table 2. Effect of cultivation method on yield and yield attributes of chickpea in Kandahar province of Afghanistan

Treatment	Pod Plant -1	Grain pod-1	Test Weight (gr)	Grain yield (t ha-1)	Straw yield (t ha-1)	Biological yield (t ha-1)	Harvest index
Cultivation method							
Raised bed	20.15	1.38	207.44	1.21	1.33	3.44	27.44
Flatbed	19.72	1.16	206.83	1.06	1.16	2.83	26.83
SE m ±	0.06	0.02	0.07	0.01	0.02	0.09	0.09
CD(P=0.05)	0.43	0.16	0.51	0.11	0.16	0.59	0.59

Table 3. Effect of cultivation method on economics attributes of chickpea in Kandahar province of Afghanistan

Treatment	Cost of cultivation (AFN ha-1)	Grass returns (AFN ha-1)	Net returns (AFN ha-1)	Benefit: Cost ratio
Cultivation method				
Raised bed	26989	104795	76854	2.78
Flatbed	26793	102980	76400	2.75
SE m ±	-	3626.83	3562.23	0.28
CD(P=0.05)	-	11498.81	11312.15	0.41

Economics attributes

Data about the cost of cultivation, gross returns, net returns and benefit-cost ratio have been presented in Table 2 Cost of cultivation (AFN ha-1) was worked out treatment-wise. The common cost of cultivation for all treatments was added to the respective additional cost involved in each treatment. Cost of cultivation was different sowing methods for chickpea. The maximum cost of cultivation (26989AFN ha-1) was recorded at the cultivation method of the raised bed. Whereas, the minimum cost of cultivation (26793 AFN ha-1) was recorded at the flatbed method. Bhargav, K. S., et al. (2018) and Basir, A. et al. (2008) noticed that the cultivation method at higher levels resulted in increased cost of the cultivation raised bed method. Gross returns (AFN ha-1) were calculated plot-wise. For this purpose, grain yield was converted into AFN ha-1 at a prevailing market price of chickpea grain and straw. The sum was used for statistical analysis.

Gross returns enhanced remarkably due to the cultivation method of chickpea. The maximum gross returns (104795 AFN) of chickpea were recorded with the cultivation method of the raised bed. Similar results were also obtained by Bhargav, K. S et al. (2018) and Hemat et al. (2017), who revealed that the raises bed method increased the Gross returns. Gross returns (AFN ha-1) = Economic yield × market price of produce. For obtaining the net returns (AFN ha-1), the cost of cultivation was reduced from the gross returns of each plot. Net returns followed almost the same trend as gross returns and were positively influenced due to different sowing methods. The highest net returns (76854AFN) of chickpea were obtained from the cultivation method of the raised bed, this had a significant correlation (Ghapari et al 2017). Net returns (AFN ha-1) = Gross returns – the cost of cultivation. For the calculation of the benefit-cost ratio, the gross return was divided by the cost of cultivation. The value obtained was considered as the benefit-cost ratio. Benefit: cost ratio improved markedly due to various sowing methods. The highest benefit: cost ratio (2.78) of chickpea was recorded with the cultivation method of raised bed this had significant These finding

conform with the results of Kumar, P et al. (2017) and Roy, S. K. et al. (1995), who stated that method increased benefit: cost ratio.

CONCLUSION

It was concluded from the study that crop planted on a raised bed with pro per production technology gives good yield as well as economically feasible as compared to other methods of sowing of chickpea. Thus, the overall performance of chickpea was superior in furrow irrigated raised beds (FIRB) over other planting systems.

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Research Article

OPEN ACCESS

Influence of hot water and UV radiation on host infectivity of entomopathogenic nematode *Steinernema glaseri (*Glaser, 1932)

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ABSTRACT
Entomopathogenic nematodes act as good bio-control agents to manage lepidopteron and coleopteran pests. *Steinernematidae* and *Heterorhabditae* are considered important families in entomopathogenic nematodes. An *in-vitro* experiment was conducted to enhance the efficacy of *Steinernema glaseri* using hot water and UV radiation on final instar larvae of *Corcyra Cephalonia*. The results showed that the highest number of larvae were infected at 35 °C and 45 °C of hot water immersion. Among the UV-exposed larvae, the highest number of larvae infected was obtained by UV exposure for 10 minutes.
Keywords: *Corcyra cephalonica*, *Steinernema glaseri*, hot water, UV radiation.

INTRODUCTION

Insect pests, pathogens and nematodes are known to cause more economic damage in both agricultural and horticultural crops (Thomas, 1999). Insecticides cause more toxicity in the environment. Most insecticides are banned because of their residual effect on the soil ecosystem. Entomopathogenic nematodes act as good bio-control agents to manage lepidopteron and coleopteran pests (Gaugler, 2002). *Steinernematidae* and *Heterorhabditae* are considered important families in the entomopathogenic nematodes group ((Kaya & Gaugler, 1993).

Third-stage juveniles (J3) are the infective stage of entomopathogenic nematodes. *Xenorhabdus* and *Photorhabdus* are the bacterium associated with the intestinal region of *Steinernema* and *Heterorhabditis* infective juveniles. Infective juveniles (IJs) enter the host through spiracles, vulva, excretory pore and anal openings. With the help of labial tooth, *Heterorhabditis* spp enters into the host body and finally reaches the haemocoel. Infectivity of entomopathogenic nematodes was enhanced by physical and chemical stressors in *Tenebrio molitor* larvae (Brown, Shapiro-Ilan, & Gaugler, 2006). With this background, an *in-vitro* study was undertaken with the following objectives to assess the influence of stressors on entomopathogenic nematodes, *Steinernema glaseri.*

MATERIALS AND METHODS

Culturing of rice moth, *Corcyra cephalonica:*
Rice moth, *Corcyra cephalonica* was cultured using cumbu grains and groundnut medium. About 2kg of cumbu grains and 200g of broken groundnut were taken in a plastic tray. Eggs of *C. cephalonica* were obtained from the Department of Entomology, TNAU, Coimbatore. One cc of *C. cephalonica* eggs was inoculated in 2.25 kg medium in a plastic tray. This plastic tray was covered with a cotton cloth. The final instar larvae of *C. cephalonica* were collected 25 days after egg hatching and used for further experiments.

Culturing of entomopathogenic nematodes:
Culture of entomopathogenic nematodes, *Steirnernema glaseri* was obtained from the Department of Nematology, TNAU, Coimbatore. A Whatmann No.1 filter paper was placed in the bottom of a 9cm Petri plate. About one ml (200 IJs) of nematode (*S. glaseri*) suspension was inoculated on the filter paper. After inoculation of nematodes, ten larvae of rice moth, *C. cephalonica* was placed on the filter paper. These plates were sealed with Klin film and incubated for three days for *S. glaseri* infection.

Preparation of Modified White traps:
A small petriplate (5cm) is filled with plaster of Paris. The plate with plaster of Paris was placed in the bottom of Petri-plate. The surface of plaster of Paris was wet sparingly. Placed the *S. glaseri* infected insect larva on the plaster of Paris. Sterile water was added to the Petri-dish. Infective juveniles were collected in the water after crawling on Plaster of Paris (JL Woodring, 1988).

Mass culturing of entomopathogenic nematodes:
The infective juveniles (IJs) of *S. glaseri* emerged out from the infected insect larvae on the 3rd day after inoculation. The IJs were washed with the sterile

distilled water four times and then excess water was decanted. The nematode suspensions were stored in a BOD incubator (Genuine model) at 20° C. A drop of Triton X was added to *S. glaseri* suspensions to avoid stickiness of nematodes.

Inducing Physical Stressors to Rice moth, *C. cephalonica:*

Immersion of *C. cephalonica* in hot water:

The final instar larvae of the rice moth, *C. cephalonica* were immersed in hot water at different temperatures *viz.*, 35°, 40° and 45° C for ten minutes. Control was maintained by immersing larvae in tap water for ten minutes. The hot water stressed larvae were inoculated with 0.5 ml (100 IJs) of *S. glaseri* . After the infection of *S. glaseri* infected larvae were transferred to Modified White's trap. The experiment was conducted in a Completely Randomized Design with six replications.

Exposure to UV radiation on *C. cephalonica* :

Final instar larvae of *C. cephalonica* were exposed to UV rays in a Laminar Air Flow chamber (Clean Air instruments) at different time intervals *viz.*,10, 20 and 30 minutes. The larvae were maintained at normal light (room temperature) served as control. UV stressed larvae were inoculated with 0.5 ml (100 IJs) of *S. glaseri.* After the infection, the larvae were transferred to Modified White's trap.

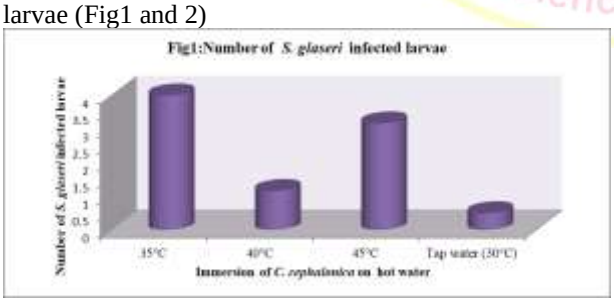
Statistical analysis

The data obtained from above-mentioned experiments were subjected to statistical analysis following the method formulated by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

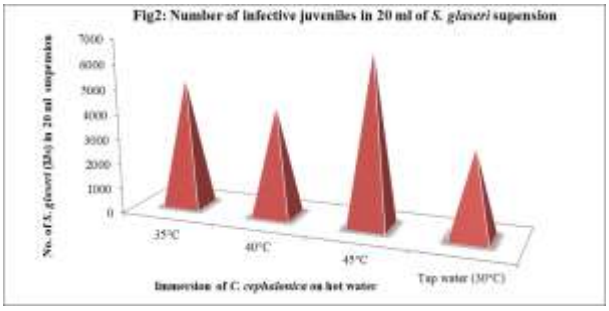
Effect of Hot water immersion on *C. cephalonica*:

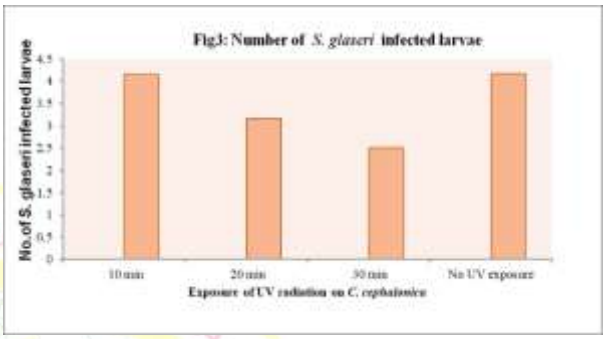
Immersion of *C. cephalonica* in hot water showed a positive influence on the infectivity of *S. glaseri*. The highest number of larvae was infected at 35 °C which was on par with the number of infected larvae at 45 °C. The lowest number of infective larvae was observed in treatment with tap water. However, there was no increase in the number of juveniles that emerged from infected larvae (Fig1 and 2)

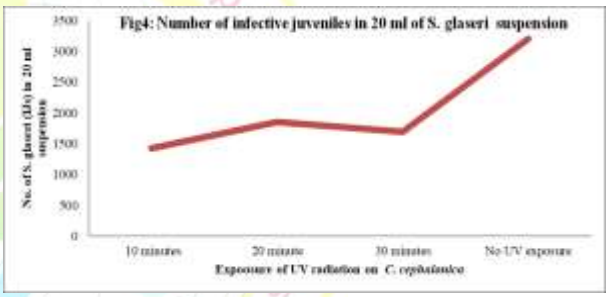


Effect of UV radiation exposure on *C. cephalonica*:

Among the UV-exposed larvae, the highest number of larvae infected was obtained by UV exposure for 10 minutes. Exposure to *C. cephalonica* for 30 minutes reduced the number of infected larvae to an extent of 66.8 per cent compared to the control. On the other hand, there was no influence of UV exposure on the number of juveniles that emerged (Fig 3 and 4).







Exposure to hot water on *C. cephalonica*

Inducing stress on *C. cephalonica* by immersing it in hot water slightly improved the infection rate. The final instar larvae of *C. cephalonica* were inactive immediately after immersing in hot water. Hence, the present study was restricted up to 45° C but the results obtained by (Brown *et al.*, 2006) are contradictory to those where treatment in hot water at 65° and 70°C increased *Tenebrio molitor* infection by *H. bacteriophora.* The variation in cuticle properties of *C. cephalonica* and *T. molitor* might be the reason for difference in temperature tolerance. The observations of present study revealed that immersion of *C. cephalonica* in hot water initially inactivated the insect and softened the cuticle. This might have facilitated the improvement in the infectivity of entomopathogenic nematodes.

UV radiation exposure on *C. cephalonica:*

UV radiation on the larvae of *G. mellonella* increased the infectivity of *S. glaseri* in the current investigation. Studies by (Herlin, Stevens, & S, 2015) showed that UV radiation altered the lifecycle of *C. cephalonica.* This finding proved that UV exposure can reduce the lifecycle of insects which can also change the morphological characteristics.

CONCLUSION

It is speculated that there might be modification in the external layer of cuticle which helped the entomopathogenic nematodes to penetrate and thus resulted in increased infectivity of *S. glaseri* in the present study.

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Research Article

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Effect of pre-sowing treatment of chemicals on sprouting of newly harvested potato at Kavre, Nepal

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ABSTRACT
The experiment was carried out to study the effect of different chemical treatments on the sprouting of newly harvested potato tuber at Banepa, Kavrepalanchowk, Nepal. The experiment was carried out in CRD (Completely Randomized Design) in a room with seven treatments and four replications. Janakdev variety of potato was treated with seven different treatments i.e., control, cytokinin (2ml/lit, 3ml/lit), hydrogen peroxide (20mM, 40mM), and gibberellic acid (40 ppm, 50ppm). The research was conducted from March to June 2022. Different chemicals with different concentrations were used in this experiment. Tubers were soaked in treatment solution for 2 hours, allowed to dry in shade, and kept in a dark room on plastic trays. The dormancy breakage, first emergence of sprout, number of sprouts per tuber, and sprout length per tuber were recorded and analysed. Among the different chemical treatments used in the experiment, gibberellic acid 50 ppm showed the first emergence of sprout at 13.38 days compared to the control (28.28). It has decreased the dormancy period by 31.96 days compared to the control. Also, 50 ppm gibberellic acid showed the highest number of sprouts per tuber and sprout length per tuber in comparison to other treatments followed by 40 ppm gibberellic acid. In the overall result, it is found that an increase in the concentration of different treatments increases the sprout's number and decreased the dormancy period. However, an increase in concentration increases the sprout length in GA3 but decreases the sprout length in cytokinin and hydrogen peroxide.
Keywords: Concentration, Dormancy, Gibberellic acid, Security.

INTRODUCTION

After reaching physiological maturity, the potato (*Solanum tuberosum* L.) seeds may enter a state of deep dormancy, during which potato seeds do not germinate after planting. Even when placed under optimum germination conditions, tubers do not sprout during the physiological stage of dormancy (Sonnewald & Sonnewald, 2014). Depending on genotype and pre- and post-harvest circumstances, the dormancy duration ranges from 2 to 3 months. For farmers to be able to preserve their produce for the desired period under conventional storage conditions or in refrigerated infrastructure, it should be assessed before releasing any variety (Mani, Bettaieb, Doudech, & Hannachi, 2014).

Potato (Solanum tuberosum L.) is considered the most important crop of food security and one of the fourth most important crops after wheat, rice, and maize in the world. It is an important cash crop to address food insecurity and reduce poverty among smallholder farmers in a developing country like Nepal (Timsina, Kafle, & Sapkota, 2011). According to Sapkota & Bjaracharya (2017), potato cultivation is popular among farmers due to its wider adaptability, high yield potential, and high demand which contribute about 6.57 and 2.17% to AGDP and GDP respectively. It also serves as a healthy replacement for most cereal crops and provides more calories, vitamins, and nutrientsper area of land sown than other staple crops (Nunn & Qian, 2011). Potato tuber contains 70-80% water, 20.6% carbohydrate, 2.1% protein, 0.3% fat, 1.1% crude fibre, and 0.9% ash (Gemmechu, 2017).

Even in the best sprouting conditions (darkness, 15 to 20 °C, relative humidity of around 90%), dormancy is a physiological state characterized by a period during which autonomous sprout growth does not occur. Dormancy is recognized as the time between tuber initiation and the beginning of sprouting. Postharvest dormancy is employed for practical purposes because the dormancy period is difficult to determine (Virtanen, Haggman, Tegefu, Valimaa, & Seppanen, 2013) and is defined as the period from dehaulming to the time when 80% of tubers shows sprouts at least 2 mm long (Pande, PC, Singh, Pandey, & Singh, 2007).

A dormancy duration provides information on how long a potato will be stored before starting to sprout. The

period of dormancy affects how to choose types for short- or long-term storage, when to use products to prevent sprouting, and how to sell the potatoes. When sprouting starts, harmful quality issues include altered glucose status, an increase in respiration rate, further weight loss, and problems with storage management like blocked airflow emerge. Depending on the season and target seed market, seed manufacturers may need to speed up or slow down sprout development (Salimi, Afsari, Hosseini, & Struik, 2010). Tuber dormancy is an adaptation of potato ontogeny providing for the successful reproduction of Solanum tuberosum species. For industrial purposes, it is preferable to keep potatoes in storage for a long time, but overly prolonged dorman cy hinders seed tuber sprouting. (Bajji, Mahmoud , Frederic , Jorge , Rojas , & Patrick , 2007). So, for seed potato multiplication, rapid post-harvest disease testing, and early production in the field or greenhouse breaking of tuber dormancy are highly important (Coleman, 1983).

Sprouts begin to grow vigorously after emerging from dormancy, with the development of roots at their bases. At this point, tubers change from being a storage organ to a source of nutrients and energy for sprouts that are still developing (Struik, Lommen, Haverkort, & Storey, 2007). To terminate premature dormancy and induce sprouting there are diverse ranges of physical, chemical, and hormonal treatments (Shuttle J. C., 2007). Chemicals such as hydrogen peroxide, cytokinin, gibberellic acid, etc. are used for initiating sprouts. Ascorbate peroxidase and glutathione peroxidase will take over to ensure the metabolism of hydrogen peroxide and, consequently, release dormancy when catalase is suppressed by the application of hydrogen peroxide, which makes the intracellular hydrogen peroxide longer available for them than for catalase. (Bhate & Ramasama, 2009). Shuttle (2004) observed that in comparison to the end of dormancy, sprout growth was more impacted by endogenous gibberellin content. Hemberg (1985) mentioned that exogenous cytokinin can be used to break potato tuber dormancy, and endogenous cytokinin levels rise before dormancy termination.

MATERIALS AND METHODS

Experimental site and duration:

The research was conducted in Banepa Municipality of Kavre district, Nepal. It lies between 27.63 ºN latitude and 85.52 ^{0}E and is located at a height of <300 m to 3000 m (Distancesto, 2022). It covers 1.73% of the total area of Nepal and has an area of 1396 sq. km. The annual rainfall is about 2,500 mm and temperatures vary from 7 ºC to 27 ºC. The research was conducted from March to June 2022.

Experimental treatments and design:

There were 7 treatments using different concentrations of control, Cytokinin (2ml/lit and 3ml/lit), Hydrogen peroxide (20 mM and 40 mM), and Gibberellic acid (40 ppm and 50 ppm). 1 kg of tubers per experimental unit was used. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Tubers were kept for sprouting at room temperature in CRD. Altogether there were 21 experimental units.

Sample collection and preparation of chemical treatments:

The tubers required for the research experiment were collected locally from Panauti municipality, Kavrepalanchowk which were harvested at Chaitra 10, 2078. Janakdev variety was taken for the study purpose as this variety was extensively cultivated by the farmers of this region. Medium-sized tubers (25-35 gram) were selected for research purposes after proper grading and removing the soil and dirt from them. The treatments were prepared by dissolving the respective concentration of chemicals in the lukewarm water except for Gibberellic acid. Gibberellic acid was first dissolved in the locally available alcohol and then mixed with water. The tubers were first washed with tap water and dipped in the chemical treatments for two hours. In the case of control, tubers were dipped in lukewarm water for two hours. After two hours, the tubers were dried and kept in a dark room for the remaining days for observation.

Data observation:

Five tubers were randomly selected from each plot and data was collected at 15 days intervals. The parameters of the research were days to the first emergence of sprouts, days to dormancy breakdown, the number of sprouts per tuber, and sprout length per tuber.

Statistical analysis:

The data recorded throughout the experimental period were tabulated in Ms-Excel and subjected to R state software for statistical analysis. Data were subjected to one-way treatment analysis of variance (ANOVA) and significant mean differences were compared by using Duncan's Multiple Range Test (DMRT) at 0.05 percent level of significance.

RESULTS AND DISCUSSION

Days to the first emergence of sprouts:

Table 1 shows the effect of treatment with various concentrations of different chemicals on days to the first emergence of sprouts of potato tuber. The experiment showed that there is a significant effect of treatment with various concentrations of chemicals over control on the days of the first emergence of sprouts. Minimum days to the first emergence were observed in Gibberellic acid at 50 ppm (13.38) followed by Gibberellic acid at 40 ppm (14.45). Gibberellic acid was followed by cytokinin with 3ml per lit and 2 ml per lit (16.60 and 17.83 respectively) and Hydrogen peroxide with 20 mM and 40 mM (18.63 and 19.67 respectively). The experiment showed the maximum number of days to the first emergence in the control (28.28). From the overall result, it can be concluded that Gibberellic acid gives better efficiency for the days to the first emergence of sprouts than other treatments and control throughout the observation. The result is in agreement with the finding of other researchers Rahman, Haque, Karim, & Ahmed, (2006), Virtanen, Haggman, Tegefu, Valimaa, & Seppanen,

(2013), Shibairo, et al., (2006). Rahman, Haque, Karim, & Ahmed, (2006) had shown that the increasing concentration of GA3 resulted in a decrease in the number of days to 50% sprouting. Therefore, the results suggest that GA3 should be used for the termination of dormancy and promotion of sprouts of potato seed tubers. In absence of GA3, cytokinin followed by hydrogen peroxide can be used to break down the dormancy and initiation of sprouts.

Table 1. Effect of different chemical doses on days of the first emergence of sprouts on potato tuber

Treatment	Days of the first emergence of sprout
Control	28.28[a]
Cytokinin (2ml/l)	17.63[d]
Cytokinin (3ml/l)	16.60[e]
Hydrogen peroxide(20mM)	19.67[b]
Hydrogen peroxide(40mM)	18.63[c]
Gibberellic acid (40ppm)	14.45[f]
Gibberellic acid(50ppm)	13.38[g]
LSD	0.37
SEM (+-)	0.122
F-Probability	<0.001
CV%	1.22
Grand mean	17.38

Note: CV=Coefficient of variation, LSD=Least Significant Difference, SEM=Standard Error of Mean. This means in the column with the same letter (s) in superscript indicates no significant difference between treatments.

Days to dormancy breakdown:

The results from this experiment revealed that the application of different concentrations of various chemicals shows significant differences in the number of days for breaking the dormancy of potato tuber compared to the control as shown in Table no. 2. The minimum days to break the dormancy was observed in 50 ppm Gibberellic acid with (32.42) which was followed by 40 ppm Gibberellic acid (36.92). The maximum days to break the dormancy of potato was observed in control (64.38). The result of this research regarding days for breaking the dormancy is by the finding of Asalfew (2016) and Shibairo, et al (2006) whom they reported that dipping treatment of 40 and 50 ppm reduced dormancy period by 18 days and 20 days, respectively. This finding is in line with Turnip, Siregar, & Damanik (2020) who stated that the soaking of the potato tuber seeds with cytokinin solution 45 days after harvesting time fastened the dormancy release time by 12.58 days compared to the time without soaking the potato tuber seeds with cytokinin solution. In addition, compared to the control, hydrogen peroxide enhanced the proportion of sprouting tubers (Mani, Bettaieb, Doudech, Hannachi, Mariem, & Mariem, Effect of hydrogen peroxide and thiourea on dormancy breaking of microtubers and field-grown tubers of potato, 2013).

Table 2. Effect of different chemical doses on days of dormancy breaking of sprouts on potato

Treatment	Days for dormancy breakdown
Control	64.38[a]
Cytokinin (2ml/l)	48.37[d]
Cytokinin (3ml/l)	44.53[e]
Hydrogen peroxide(20mM)	55.30[b]
Hydrogen peroxide(40mM)	53.32[c]
Gibberellic acid (40ppm)	36.92[f]
Gibberellic acid(50ppm)	32.42[g]
LSD	0.39
SEM (+-)	0.13
F-Probability	<0.001
CV%	0.46
Grand mean	47.89

Note: CV=Coefficient of variation, LSD=Least Significant Difference, SEM=Standard Error of Mean. This means in the column with the same letter (s) in superscript indicate no significant difference between treatments.

Number of sprouts (sprout density):

Table no.3 shows the effect of treatment with various concentrations of different chemicals on the number of sprouts per tuber. At 15 DAT, the highest numbers of sprouts were observed in 50 ppm Gibberellic acid (6.83) and the minimum number of sprouts was observed in control (0.00). At 30 DAT, the maximum number of sprouts per tuber was observed in 50 ppm Gibberellic acid (7.33) which is at par with 40 ppm Gibberellic acid (6.50). The minimum number of sprouts per tuber was observed in the control (2.16). At 45 DAT, the highest number of sprouts was observed in 50 ppm Gibberellic acid (7.50) which was at par with 3ml/lit Cytokinin (6.83) followed by 40 ppm Gibberellic acid (6.50). At 60 DAT, the number of sprouts per tuber was found to be significantly higher in 50 ppm Gibberellic acid (8.17). At 75 DAT, the maximum number of sprouts was observed in 50 ppm Gibberellic acid (8.33) and the minimum number of sprouts was observed in control (5.50) and 20mM Hydrogen peroxide (5.50). At 90 DAT, the highest number of sprouts was observed in 50 ppm of Gibberellic acid (10.00). Similarly, the minimum number of sprouts was observed in control (6.00) which is at par with 20mM Hydrogen peroxide (6.17). These results are in agreement with the result of Shibairo, et al. (2006) who reported that higher concentrations of GA3 produce more sprouts. Similarly, the result is by the result of Turnip, Siregar, & Damanik, (2020) and Mani, et al. (2013) who reported that the number of sprouts increased with hydrogen peroxide than in the control.

Sprout length per tuber:

Table no. 4 shows the effect of treatment with various concentrations of different chemicals on sprout length per tuber on potato. The experiment showed that different concentrations of Gibberellic acid, Cytokinin, and Hydrogen peroxide had a significant effect on sprout

length over control. According to observations made on 30 DAT, 50 ppm Gibberellic acid produced the longest sprouts (1.51). The minimum length of sprouts (0.20) was produced by the control. At 45 DAT, the highest length of sprouts per tuber(2.20cm) was obtained in 50 ppm Gibberellic acid, and the lowest length of sprouts (0.58 cm) was observed in the control. Similarly, in 60 DAT Gibberellic acid produce the longest sprouts i.e., 3.25 cm, and the shortest sprouts were seen in control i.e.,0.77 cm which was at par with the concentration of Cytokinin and Hydrogen peroxide. At 75 DAT and 90 DAT, the maximum length of sprouts was observed in 50 ppm Gibberellic acid 3.83 cm and 4.20 cm respectively followed by 40 ppm Gibberellic acid 2.58 cm and 3.00 cm. The minimum length of sprouts was produced by control on both of the days of observation. At 75 DAT, the control produced 0.95 cm and at 90 DAT, it produced 1.20 cm. These findings are similar to the result of Rossouw (2008) who indicate that a lower concentration of cytokinin (0.5BA treatment) resulted in more sprout growth (14.6 mm) than a higher concentration of cytokinin (1BA) resulted in less sprout growth (8.4 mm). The result thus obtained is in accordance with Soares, et al., (2021) who stated that the menthol and H2O2 + menthol treatments result in smaller sprouts but the isolated application of H2O2 stimulated sprout growth.

Table 3. Number of sprouts per tuber induced by different chemical doses on potato tuber

Treatment	Number of sprouts per tuber					
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Control	0.00^{e}	2.16^{d}	3.50^{d}	4.17^{e}	5.50^{d}	6.00^{d}
Cytokinin (2ml/l)	5.67^{abc}	6.00^{ab}	6.33^{abc}	6.50^{bcd}	6.83^{bc}	7.66^{bc}
Cytokinin (3ml/l)	5.00^{bcd}	6.17^{ab}	6.83^{a}	7.00^{b}	7.17^{b}	7.33^{c}
Hydrogen peroxide(20mM)	4.17^{d}	4.33^{c}	5.17^{c}	5.50^{d}	5.50^{d}	6.17^{d}
Hydrogen peroxide(40mM)	4.50^{cd}	5.00^{bc}	5.50^{bc}	5.83^{cd}	6.00^{cd}	6.50^{d}
Gibberellic acid(40ppm)	6.00^{ab}	6.50^{a}	6.50^{ab}	6.83^{bc}	7.33^{ab}	8.33^{b}
Gibberellic acid(50ppm)	6.83^{a}	7.33^{a}	7.50^{a}	8.17^{a}	8.33^{a}	10.00^{a}
LSD	1.24	1.34	1.19	1.01	1.01	0.83
SEM (+-)	0.41	0.44	0.39	0.33	0.33	0.27
F-Probability	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CV%	15.39	14.26	11.54	9.19	8.66	6.40
Grand mean	4.60	5.36	5.90	6.29	6.67	7.43

Note: CV=Coefficient of variation, LSD=Least Significant Difference, SEM=Standard Error of Mean. Means in the column with same letter (s) in superscript indicate no significant difference between treatments.

Table 4. Sprout length (cm) induced by different chemical doses

Treatment	Sprout length per tuber(cm)				
	30 DAT	45 DAT	60 DAT	75 DAT	90DAT
Control	0.20^{d}	0.58^{de}	0.77^{c}	0.95^{d}	1.20^{d}
Cytokinin (2ml/l)	0.35^{cd}	0.70^{cde}	0.90^{c}	1.23^{cd}	1.53^{c}
Cytokinin (3ml/l)	0.28^{cd}	0.50^{e}	0.77^{c}	0.98^{cd}	1.43^{cd}
Hydrogen peroxide(20mM)	0.48^{c}	0.83^{c}	1.03^{c}	1.28^{c}	1.63^{c}
Hydrogen peroxide(40mM)	0.51^{c}	0.70^{cd}	0.93^{c}	1.08^{cd}	1.50^{c}
Gibberellic acid(40ppm)	1.05^{b}	1.62^{b}	2.30^{b}	2.58^{b}	3.00^{b}
Gibberellic acid(50ppm)	1.51^{a}	2.20^{a}	3.25^{a}	3.83^{a}	4.20^{a}
LSD	0.27	0.23	0.28	0.31	0.30
SEM (+-)	0.08	0.07	0.09	0.10	0.09
F-Probability	<0.001	<0.001	<0.001	<0.001	<0.001
CV%	24.3	12.48	11.39	10.30	8.16
Grand mean	0.63	1.03	1.42	1.72	8.16

Note: CV=Coefficient of variation, LSD=Least Significant Difference, SEM=Standard Error of Mean. Means in the column with same letter (s) in superscript indicate no significant difference between treatments.

CONCLUSION

Dormant potato tuber takes more time for sprouting so, the growth phase of potato plant become longer. The result of this study indicated that, all methods of treatments have an effect on the first emergence of sprouts, days to dormancy break, number of sprouts per tuber, and sprout length per tuber. Dipping treatments with 50 ppm gibberellic acid is found to be best for breaking dormancy with more numbers of sprouts and the highest sprout length in comparison to other treatments. After Gibberellic acid (both 40 ppm and 50 ppm), cytokinin can be used for initiating sprouting but hydrogen peroxide is not found quite significant as sometimes it may be used by other for sprouting inhibitors. Therefore, gibberellic acid with 50 ppm is recommended for initiating sprouting in newly harvested potato.

CONFLICT OF INTEREST

The author here declares that there is no conflict of interest in the publication of this article.

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Research Article

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In vitro screening for Acetylcholinesterase Inhibition and Antioxidant activity of selected Medicinal Plants

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ABSTRACT
In the present study, four plant extracts (*Allium sativum* L., *Desmodium gangeticum* L., *Eclipta alba* L., and *Piper longum* L.) were considered and checked for their acetylcholinesterase inhibitory activity which is the main true enzyme which hydrolyses acetylcholine in the body. The dried coarse powder of plants was extracted with methanol by cold extraction method. The resultant was assessed for acetylcholinesterase (AChE) inhibitory activity by Ellman's method with few modifications. The antioxidant activity was determined by DPPH (1, 1-diphenyl-2-picrylhydrazyl) and FRAP (Ferrous reducing Antioxidant power) assays. Quantitative phytochemical (phenolic contents) analysis of endogenous substances was performed by standard spectrophotometric methods. Plant extract significantly inhibited AChE activity. Additionally, the plant extracts exhibited strong radical scavenging activity against DPPH and reduced the Ferric ion (FRAP) significantly when compared to that of standards. Plant extracts were found to be rich in phenolic (gallic acid equivalent/g of dry extract) content. Furthermore, a positive correlation was observed between the total phenolics and antioxidants as well as the anticholinesterase potential.
Keywords: Alzheimer's disease (AD), Acetylcholine (ACh), Acetylcholinesterase (AChE), DPPH, Antioxidant activity, FRAP, Ascorbic acid, Free radical.

INTRODUCTION

Inhibition of Cholinesterases, mainly Acetylcholinesterase (AChE) and therefore prevention of acetylcholine degradation in synapses of the cholinergic system is one of the most accepted palliative therapy opportunities for Alzheimer's disease (AD) today (Birks, 2006). Since the introduction of the first cholinesterase inhibitor in 1997, most clinicians would consider the cholinergic drugs, donepezil, rivastigmine (Birks *et al*., 2009), and galantamine (Prvulovic *et al*., 2010), to be the first-line pharmacotherapy for mild and moderate AD. The most that these drugs could achieve is to modify the manifestations of AD. Due to a lack of selectivity of cholinesterase inhibitor drugs on the market, AD patients suffer from side effects like nausea or vomiting.

The enzyme acetylcholinesterase (AChE) catalyses the hydrolysis of the ester bond of acetylcholine (ACh) to terminate the impulse-transmitted action of ACh through cholinergic synapses (Stryer, 1995). Although the basic reason for Alzheimer's disease (AD) is not clear so far, AD is firmly associated with impairment in cholinergic transmission. Several AChE inhibitors have been considered candidates for the symptomatic treatment of AD as the most useful relieving strategy (Howes *et al*., 2003).

Plants have formed the basis of the traditional medicine system that has been the way of life for thousands of years. Mostly, herbs and spices contain polyphenols which are the most powerful natural antioxidants and are highly valued for their antioxidant, anti-ageing antimicrobial effects. Antioxidants are widely used as ingredients in dietary supplements and are exploited to maintain health and prevent oxidative stress-mediated diseases. Antioxidant compounds like phenolic acids, polyphenols and flavonoids inhibit the mechanism that leads to degenerative diseases (Hamid *et al*., 2010).

The main characteristic of an antioxidant is its ability to trap free radicals. Highly reactive free radicals and oxygen species are present in biological systems from a wide variety of sources. These free radicals may oxidize nucleic acids, proteins, lipids or DNA and can initiate degenerative disease. Antioxidant compounds like phenolic acids, polyphenols and flavonoids scavenge free radicals such as peroxide, hydroperoxide or lipid peroxyl and thus inhibit the oxidative mechanisms that lead to degenerative diseases (Prakash *et al*., 2007).

The alkaloid piperine from the spice family Piperaceae has been reported to possess poly-pharmacological activities including anti-depressant and cognitive-enhancing effects. It has been suggested that its

neurocognitive benefits may be via its activity on the cholinergic system, particularly on the enzyme acetylcholinesterase (AChE), a pharmacological target for neurodegenerative diseases such as Alzheimer's disease (AD). Piperine, as seen in the historic remedies, is a vital compound that exerts antipyretic and anti-inflammatory properties for medicinal uses. Other biological effects that piperine possesses are; analgesic (Gupta *et al*., 2000), antidepressant (Lee *et al*., 2005), cognitive enhancing (Wattanathorn *et al*., 2008), cytoprotective and anti-oxidant (Selvendrian *et al*., 2003). The antioxidant properties in piperine have also been linked to improvements in cognitive function.

Desmodium gangeticum (L.) commonly known as Salparni, belongs to the family Papilionaceae. It is widely distributed mainly in the Himalayan territory at elevations up to 5,000 feet. It is also distributed in China, Philippine and tropical Africa (Sagar *et al*., 2010). Traditionally, the plant has been used as an antipyretic, diuretic, astringent, anthelmintic, laxative, and in the treatment of dementia (Ma *et al*., 2011). The plant has been reported to exhibit anti-inflammatory, antibacterial, antidiabetic, hepatoprotective, antiulcer, locomotor and wound-healing activities. *D. gangeticum* has been reported to contain alkaloids, flavonoids, steroids and terpenoids (Bhattacharjee *et al*., 2013). The aqueous extract of *Desmodium gangeticum* has been shown to reverse scopolamine-induced amnesia by decreasing whole-brain acetylcholinesterase activity (Joshi and Parle, 2006).

Garlic (*Allium sativum* L.) is one of the World's oldest medicines and has been employed not only for flavouring but also as a medical herb for its diverse biological activities, including anti-carcinogenic, antiatherosclerotic, antithrombotic, antimicrobial, anti-inflammatory and antioxidant effects (Augusti, 1996, Wargovich *et al*., 1996, Hunter *et al*., 2005, Brace, 2002, Leelarungrayub *et al*., 2006). The antioxidant activity of Allium spp. has been attributed mainly to a variety of sulphur-containing compounds and their precursors (Yin *et al*., 2002, Singh *et al*., 2004). Scientific evidence shows that allicin, diallyl disulphide and diallyl trisulphide appeared to be the main antioxidative compounds (Kim *et al*., 1997, Rabinkov *et al*., 1998). In addition, the antioxidant activity is also related to other bioactive compounds: dietary fibres, microelements (especially Se) and polyphenols (Lanzotti, 2006, Gorinstein *et al*., 2005).

Eclipta alba (L.) Hassk (synonym *Eclipta prostrata*) is an annual herbaceous plant, erect or prostrate, belonging to the Asteraceae family. It is also known as Bhringaraj in Ayurveda which has been generally utilized for a very long time as a part of the conventional prescription for ailments especially related to the liver and hair. There are four main varieties of the herb *Eclipta alba* based on the colour of their blossom, that is, red, yellow, white, and blue. The white and yellow ones assume an essential part in traditional medicine, but it is the white species (*Eclipta alba*) that is most commonly harvested for its therapeutic advantages as it grows wildly in moist places, as a weed, and it can be easily propagated. The extracts from the leaves and flowers of this medicinal herb can be applied in numerous ways, both topically and internally, to soothe many ailments. *Eclipta alba* shows versatile pharmacological effects that include hair growth, antimicrobial, antioxidant, anti-inflammatory, analgesic, antinociceptive, antileprotic, antihaemorrhagic, antimyotoxic, antiviral, antihepatotoxic, diuretic, hypotensive, hypocholesterolemic, hypotensive, immunomodulatory, nootropic, ovicidal, and spasmogenic activity (Sawant *et al*., 2004, Thakur and Mengi 2005, Pandey *et al*., 1997).

MATERIALS AND METHODS

Preparation of various extracts: All the above-mentioned plant materials were dried in shade and powdered in a grinder. The plant material was exhaustively extracted successively using methanol. The solvents from crude extracts were recovered under reduced pressure using rotary vacuum evaporator. Various extracts were screened for detection of Acetylcholinesterase and antioxidant activity. Extracts were also analysed for total Phenolic contents.

Acetylcholinesterase (AChE) inhibition assay: AChE Assay

AChE inhibiting activity was measured by the spectrophotometric method developed by Lopez *et al*., 2002 inspired by Ellman *et al*., 1961. The enzyme activity was determined by observing the increase of a yellow colour produced from thiocholine (resulting from acetylthiocholine hydrolysis by an enzyme) when it reacts with DNTB (5, 5'-dithiobis-2-nitrobenzoic acid) ion. This can be detected at 405 nm (Rhee *et al*., 2001). Ten per cent methanol in buffer was used as negative control (enzyme activity without extract), Tris-HCl buffer 50 mM, pH 8, 0.1% BSA as enzyme blank and Galanthamine as the reference standard. The substrate ATCI (Acethylthiocholine Iodide) 15 mM was prepared in water and enzyme (0.22 U/mL) in Tris-HCl buffer 50 mM, pH 8, 0.1% BSA. The kinetic reaction was followed for 3 min. The percentage of enzyme inhibition (I %) of the enzymatic reaction was determined by the following equation:

$I\% = (E - S) / E \times 100$

where E: The substrate hydrolysis kinetics by enzyme without test compound

S: The substrate hydrolysis kinetics by enzyme with the test compound.

Determination of Antioxidant activity: DPPH Assay

Free radical scavenging activity of different extracts was tested against a methanolic solution of 1, 1 diphenyl 2-picryl hydrazyl (DPPH). Antioxidants react with DPPH and convert it to 1-1-diphenyl -2-picryl hydrazine. The degree of discoloration indicates the scavenging potential of the antioxidant extract. The change in the absorbance produced at 517nm has been used as a measure of antioxidant activity. The samples of different extracts were prepared in various concentrations viz.

100, 150, 200, 250 µg/ml in methanol. 1 ml sample of the above concentrations was mixed with an equal volume of 0.1mM methanolic solution of DPPH (0.39mg in 10 ml methanol). An equal amount of methanol and DPPH was added and used as a control. Ascorbic acid solutions of various concentrations viz. 100, 150, 200, 250 µg/ml in distilled water were used as standard. After incubation for 30 minutes in dark, absorbance was recorded at 517 nm. The experiment was performed in triplicates. Percentage scavenging was calculated by using the following formula:

Scavenging effect (%) = $(A_0-A_1/A_0) \times 100$

A_0 is the absorbance of the control reaction.

A_1 is the absorbance in presence of all the extract samples and reference

A graph was plotted with concentration (µg/ml) on X axis and % scavenging on the Y axis and IC^{50} values were calculated, which represents the concentration of the scavenging compound that caused 50% neutralization (Sreejayan and Rao 1996).

FRAP Assay

Determination of Reducing Power: Reducing power is associated with antioxidant activity and may serve as a significant reflection of the antioxidant activity. It describes how easily one substance can give electrons to another. A powerful reducing agent is keen to donate electrons. This method measures the ability of antioxidants to reduce ferric ion. Reducing power was investigated using the method developed by Yen (Yen and Duh 1993). The samples of different extracts were prepared in various concentrations viz. 200, 400, 600 and 800 µg/ml in distilled water. 1.25 mL of sample aliquots were mixed with 1.25 mL of sodium phosphate buffer (0.2 M, pH 6.6) and 1.25 mL of 1% potassium ferricyanide ($K_3Fe(CN)_6$). The mixtures were incubated at 50 ºC for 20 minutes. The resulting solution was cooled rapidly, mixed with 1.25 mL of 10% trichloroacetic acid and centrifuged at 3,000 rpm for 10 min. The supernatant (2.5 mL) was taken out and immediately mixed with 2.5 mL of distilled water and 500 µL of 1.0 % ferric chloride ($FeCl_3$) was then added. After incubation for 10 min, the absorbance (abs) against blank was determined at 700 nm. All samples were assayed in triplicate. The ascorbic acid standard was utilized for comparison.

Determination of Total Phenolic Content:

Folin-Ciocalteu Total Phenolic Assay

This assay measures the change in colour as metal oxides are reduced by polyphenolic antioxidants such as gallic acid and catechin, resulting in a blue solution with maximal absorption at 765 nm. The standard curve is prepared using gallic acid, and results are reported as gallic acid equivalents. Total phenols were determined by Folin-Ciocalteu reagent. The Folin-Ciocalteu reagent is a mixture of phosphomolybdate and phosphotungstate used for the colourimetric assay of phenolic and polyphenolic antioxidants. However, this reagent does not only measure total phenols and will react with any reducing substance. The reagent, therefore, measures the total reducing capacity of a sample, not just the level of phenolic compounds. A dilute sample of different extract (0.5 ml of 1:10 g/ml) or gallic acid (standard phenolic compound) was mixed with Folin-Ciocalteu reagent (5 ml, 1:10 diluted with distilled water) and aqueous Na_2CO_3 (4 ml, 1 M). The mixtures were allowed to stand for 15 min and the total phenols were determined by spectrophotometric measurements at 765 nm. The standard curve was prepared using 50, 100, 150, 200, and 250 mg /L solutions of gallic acid in methanol: water (50:50, v/v). The total phenolic content was expressed as mg/g equivalents of gallic acid which is a common reference compound (Banerjee *et al*., 2008, Pourmorad *et al*., 2006).

RESULTS AND DISCUSSION

The inhibition might come from the presence of phenolic acids, flavonoids and other antioxidant compounds. Antioxidant compounds might be implicated in AChE inhibition. Recent studies bound Alzheimer's disease to an inflammatory process induced by reactive oxygenated substances. The oxidative stress intervenes, for a share, in the physiopathology of neuronal degeneration.

In vitro tests of methanolic extract of bulb of *Allium sativum* Linn. evaluated for its antioxidant property revealed DPPH, FRAP, AChE and total phenolic content effect. The antioxidant reacts with stable free radical, DPPH and converts it to 1, 1-diphenyl–2-picryl hydrazine. The ability to scavenge the stable free radical DPPH was measured by a decrease in the absorbance at 517 nm. A concentration-dependent assay was carried out with these extracts and the results are presented in Tables 1, 2 and 3. Methanolic extract of the sample showed the scavenging activity of DPPH that ranged from 16.28±0.26 to 34.48±0.36 and acetylcholinesterase activity was found in the range between 24.24±0.23 to 56.56±0.28. An assay of reducing power reveals the reductive capabilities of the bulb extracts compared to ascorbic acid. The reducing power of bulb extracts was very potent and the power of the extract was increased with increasing concentration. The absorbance values ranged from 0.292±0.22 to 1.124±0.62. The reducing power of the garlic extracts was a function of their concentration. The reducing power of the garlic extracts increased with their concentrations or on par with the results of Deore *et al* 2009. Phenolics are the widest-spread secondary metabolite in the plant kingdom. These diverse groups of compounds have received much attention as potential natural antioxidants in terms of their ability to act as both efficient radical scavengers and metal chelator. It has been reported that the antioxidant activity of phenol is mainly due to their redox properties, hydrogen donors and singlet oxygen quenchers (Rice-Evans *et al*. 1995). Therefore, in the present study, the total phenolic content present in the extract was estimated using the modified Folin- ciocalteu method. Polyphenols are used for the prevention and cure of various diseases which are mainly associated

with free radicals. The higher content of polyphenols may be attributed to the antioxidant potential of garlic.

Table 1. DPPH % scavenging of Plant extract

Conc (µg/ml)	% Scavenging DPPH (100µg/ml) MeOH extract				
	AS	DG	EA	PL	Ascorbic Acid
100	16.28± 0.26	34.48± 0.36	10.36± 0.22	14.40± 0.25	48.17± 0.43
150	22.24± 0.21	38.35± 0.56	12.36± 0.22	18.44± 0.28	66.08± 0.39
200	30.28± 0.22	40.28± 0.51	18.28± 0.28	37.95± 0.30	83.27± 0.56
250	34.48± 0.36	42.22± 0.67	24.86± 0.48	48.19± 0.34	91.26± 0.66

Each value represents the mean and standard deviation from three replicates

Table 2. AChE inhibitory activity of Plant extract

Conc. (µg/ml)	% Inhibition AChE (200 u/ml) AS	DG	EA	PL
100	24.24± 0.23	31.10± 0.52	18.52± 0.29	31.28± 0.24
150	31.26± 0.21	34.30± 0.42	24.25± 0.25	42.23± 0.28
200	42.28± 0.22	40.22± 0.20	37.26± 0.24	62.26± 0.20
250	56.56± 0.28	40.83± 0.05	46.25± 0.20	76.26± 0.24

Each value represents the mean and standard deviation from three replicates

Table 3. Reducing power ability: FRAP Assay

Conc (µg/ml)	Absorbance (700nm) MeOH extract				
	AS	DG	EA	PL	Ascorbic acid
200	0.292± 0.22	0.124± 0.12	0.202± 0.20	0.302± 0.20	0.362± 0.88
400	0.566± 0.42	0.222± 0.24	0.398± 0.18	0.596± 0.24	0.718± 0.32
600	0.824± 0.52	0.346± 0.18	0.582± 0.16	0.902± 0.26	1.086± 0.38
800	1.124± 0.62	0.420± 0.20	0.788± 0.18	1.224± 0.40	1.414± 0.42

All values in the table represent mean ± SD (n=3)

Table 4. Total phenolic content of four plants.

Plants	Conc. (µg/ml) vs Abs. (765nm)				Total phenolic content GAE mg/g
	100	150	200	250	
Allium sativum L.	0.226	0.386	0.418	0.522	15.23±0.20
Desmodium gangeticum L.	0.258	0.438	0.611	0.721	24.85±0.23
Eclipta alba L.	0.201	0.273	0.348	0.446	14.89±0.21
Piper longum L.	0.258	0.438	0.611	0.784	48.93±0.22
Mean Value ± Standard Deviation of three replicates					

So far as plant phenolics constitute one of the major groups of compounds acting as primary antioxidants or free radical terminators, it was reasonable to determine their total amount in the selected plant extract. The content of total phenols in methanolic extracts was expressed in gallic acid equivalents (GAE). The phenols contain hydroxyls that are responsible for the radical scavenging effect mainly due to redox properties. The methanolic extracts of *Allium sativum* L. had phenol content of 15.23±0.20.mg GAE/g. Absorbance vs concentration graph was plotted for the Ferric ion reduction and the phenolic content.

The inhibitory activity of AChE by *D. gangeticum* L. is presented above at a final concentration of 100-250 µg/mL. Percentage inhibition of *D. gangeticum* L. ranged from 31.60±0.52to 40.83±0.05. DPPH scavenging percentage was found in the range of 34.48±0.36 to 42.22±0.67. The amount of extract needed for 50% inhibition of DPPH free radical is known as the IC^{50} value of the extract. Lowering the IC^{50} value shows a better scavenging ability of the sample. The reducing power ability of Ferric ions in FRAP assay for DG was found to be effective as shown in Table 2. The absorbance values of the extract were in the range of 0.124±0.12 to 0.420±0.20. The standard Ascorbic acid reduced the Ferric ions significantly much higher in the range of 0.362±0.88 to 1.414±0.42 respectively. The total phenolic content in *D. gangeticum* L. was 24.85 ±0.23 mg GAE/g.

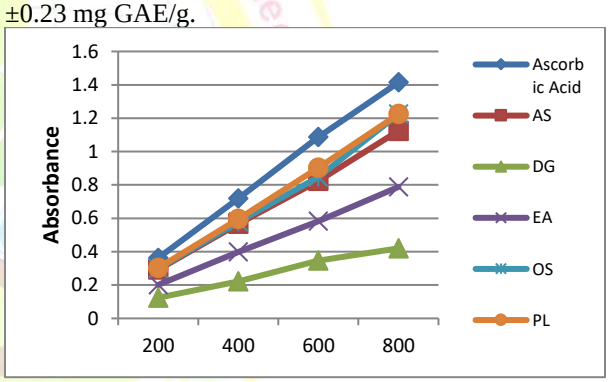

Fig. 1. FRAP Assay

The activity of *E. alba* L. was calculated as a range of 10.36±0.22 to 24.86±0.48 for DPPH whereas AChE inhibition activity was measured as a range of 18.52±0.29 to 46.25±0.20 (Table 2). The reducing power ability of Ferric ions in FRAP assay for EA was found to be effective as shown in Table 3. The absorbance values of the extract were in the range of 0.202±0.20 to 0.788±0.18. The total phenol content of *E. alba* L. was calculated as 14.89±0.21 mgGAE/g. which is the lowest among the studied medicinal plants. The highest DPPH scavenging percentage is of *Piper longum* L. and the lowest is *Eclipta alba* L. In respect of AChE inhibition activity, *P. Longum* L. showed the highest % whereas the lowest inhibition activity was of *D. gangeticum L.*

The methanolic extract of *Piper longum* L. showed a greater content of phenolics and augmented *in vitro* antioxidant activity and antiacetylcholinesterase activity. DPPH radical scavenging activity was found in the range

14.40±0.25 to 48.19±0.34. AChE inhibition percentage was between 31.28±0.24 to 76.26±0.24. Reducing power assays showed activity in the range of 0.302±0.20 to 1.224±0.40. Total phenols in *Piper longum* L. were found to be 48.93±0.22 mgGAE/g.

CONCLUSION

The overall acetylcholinesterase activity was found to be maximum in *Piper longum* L. followed by *Allium sativum* L., *Eclipta alba* L. and *Desmodium gangeticum* L, whereas DPPH radical scavenging and ferrous reducing power was maximum in *Piper longum* L. followed by *Desmodium gangeticum, Allium sativum* and lowest was found in *Eclipta alba*. (Table 1-3). Total phenol and flavonoids content were in the order, *Piper longum* followed by *Desmodium gangeticum, Allium sativum* and *Eclipta alba*.

The result of total Antioxidant activity and Total phenolic and flavonoids content showed that the plant extracts or the plants studied here can be seen as a potential source of new useful drugs. The present study reveals that the selected plants would exert several beneficial effects by virtue of their antioxidant activity and could be harnessed as drug formulation. The phytochemical characterization of the extracts, the identification of responsible bioactive compounds and quality standards are necessary for future study.

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Research Article

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Development of low-cost self-propelled multi-purpose power unit

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ABSTRACT
The self-propelled multipurpose power unit was developed in the laboratory of Farm Machinery and Power Engineering, JNKVV, Jabalpur for small farmers. The prime mower is powered by a 5hp diesel engine. The V-belt drive is provided for the transmission of power from the engine to the traction wheels. An adjustable accelerator wire is connected to the governor for adjusting the engine speed according to the requirement. The worm gear reduction unit is located at the axle having a speed reduction ratio of 20:1. A telescopic type frame is provided to support the end of the adjustable output shaft with the help of a bearing. The handle is modified to vary the height from 1.0 to 1.3 m from the ground. The additional lug cage wheel is connected to the transport wheel to increase the traction. Noise and Vibration isolators are provided between the engine and chassis to reduce the noise level and vibration. The noise level of the power unit was suitable for 8 working hr. The range of noise with load conditions is 60, 65, 70 (dB) and without load conditions 74, 79, 86 (dB), this limit of noise is under the permissible limit 90db. Vibration range according to optimum rpm 1200, rated rpm 1500 and maximum rpm 1800 so the output range of vibration in Handle 130 µm and chassis 217 µm, Handle 127 µm and chassis 198 µm, Handle 121 µm and chassis 193 µm.
Keywords: Power unit, Sound level meter and Vibration meter.

INTRODUCTION

The presence of a large number of marginal and small landholding farmers (80%) (D. Mahendra). India approves the importance of power tiller as the most suitable farm power source for field operations, because of its compact size, low cost, and versatility. A power tiller is a walking-type small tractor used for agricultural operations in most of the world. It is mainly used for field preparation sowing and other operations like Inter-culture, mower & harvesting in small agricultural fields. This power unit has gained popularity among farmers due to its rugged and reliable operation. The smallholding farmers faced many problems including poor access to modern inputs and credit, poor infrastructure, inadequate access to markets, land and environmental degradation, and inadequate research and extension services. A study about the use of Power Tiller among small farms indicated that there was a 70 % increase (Faleye T. *et. al.*) in yield. The suitability of these small prime movers can further be increased to a greater extent, if it turns out to be suitable for some left outfield operations like water lifting, winnowing, cleaning & grading operation then this unit may become the complete self-propelled multipurpose unit. In general, the available power units are developed for a specific kind of work so small and marginal farmers may not be able to purchase different machines for different operations. The solution to such a problem can be provided by the development of a small multipurpose power unit that may be a worthwhile endeavour in this context. This unit must be able to perform most field operations from tillage to post-harvest operations. The availability of multipurpose power units for marginal and small farmers may avoid the year-round maintenance of bullocks and also the high investment in tractors. This machine must be simple in design and can be fabricated & repaired by village artisans. The structure of a power unit must be so simple that it provided better manoeuvrability and better floatation for Kharif crops. The present study will be carried out for modification of the following objective by providing effective and easy power engaging & disengaging system and Modification to achieve better traction and operation comfort.

Design Consideration of Power Unit

To fulfil the above-mentioned design criterion, modification of a telescopic frame for hitching of different cutting tools and operating rotary machinery by the spliced output shaft was taken for modification in respect of the following components;

Telescopic frame
Engine
Power transmission.

power engaging & disengaging system
V-belt and pulley
Speed reduction unit
Axle
Traction wheels
Ball bearing and bushes
Output shaft
Handle and Hitching point
Telescopic frame

Telescopic frame modification is particularly important in frame of walking-type power unit lightweight reduce cost and ease of transportation. Operation and propelling power must be strong enough to resist the shock load during operation. With lightweight construction, there is considerable deflection and which leads to self-alignment necessary.

The following points were considered while modification the frame:

A proper size frame may provide the required strength and toughness so there may be no bending and twisting during operation, although flexibility is always needed field operation.

Provision to separate output shaft power according to the position of operating rotary machinery may be given.

Size of MS angle was determined based on the following assumption related to developing a power unit for intercultural operation calculation.

Determination of size of MS angle

Assumptions for the design of frame:

The number of cutting tools, no. = 3
width of the cutting tool (base), cm = 25 top
(Cutting section), cm = 10 bottom
depth of cutting, cm = 7
ground clearance, cm = 45
soil resistance, cm = 0.7 kg/cm2
row to row spacing, cm = 40

Furrow cross-section:

Cross-section of furrow was assumed trapezoidal with top width 25 cm bottom width 10 cm

Area of furrow cross-section = Top width + bottom width × depth

2

$= \frac{25+10}{2} \times 7$ = 122.2 cm2

Draft = Soil resistance × furrow cross-section

= 0.7 × 122.2 = 85.75 kg

The tool bar is subjected to torsion and bending moment due to induced draft. Three tines are to be arranged in tool bar in single row. The design is based on stress produced in the tool bar.

Draft per tine = 85.75 kg
Total draft = 85.75 x 3 = 257.25 kg

Torque on the tool bar by each tines = draft × ground clearance
= 86.75 × 45 = 3858.75 kg-cm

Total torque on the row tool bar = 3 x 3858.75 = 11576.25 kg-cm

In addition to torque, bending moment would also be produced. The tool bar can be taken as simple supported beam on the frame in between the last two tines.

The max bending moment

$$Mmax = \frac{Wl}{4}$$

Where,

W = Total wt. on the frame = 257.25 kg;
l = Total length = 70cm;

Mmax = (257.25 x 70) / 4 = 4501.88 kg-cm.

Equivalent torque due to torsion and bending moment

$Te = \sqrt{M^2 + T^2}$

Where,

Te = Equivalent torque;
M = Max Bending Moment; and
T = Torque on the tool bar.

$Te = \sqrt{4501.88^2 + 11576.25^2}$ = 12420.80 kg cm

The maximum shear stress developed on the tool bar can be obtained by using the formula.

Fs / R = T / J ---- eq1

Where,

F_S = Shear stress at any section;
R = Distance of the section from neutral axis;
T = Equivalent torque produced; and
J = Polar moment of inertia.

Assuming maximum working stress of 500 kg/cm2 at the centre of tool bar, for angle section having each side measuring d cm.

J = d4/9.6,
R = d/2

Where,

d = width of the section

Substituting than values in equation

fs/ R = T / J ……... eq2
500 / (d/2) = 12l20.80/(d4 / 9.6)
d3 = (12420.80x9.6) / (500x2)

$d = \sqrt[3]{[(12420.80x9.6)I(500x2)]}$ = 4.92 cm = 5.5 cm.

Thus, on the basis of calculations, tool bar is to be made of angle section each side measuring 5 cm.

Rectangular structures are to be fabricated for frame out of angle section of 50×50×5 mm. thickness are 5mm selected as it standard matching with ms available of 50 mm.

Engine

Engine is main power sources for the power unit.

Power = 5hp;
Speed (n) = 1200 rpm.

Calculate torque on engine output shaft

$$hp = \frac{2\pi NT}{4500}$$

Where,

hp = Horse power;
N = rpm; and
T = Torque (kg cm).

$T = \frac{5 \times 4500}{2 \times \pi \times 1200}$ = 2.98 kg cm

Design of power transmission from prime mover to wheel

A 5HP engine with 1200 rpm has been taken. The required rpm of feed shaft is 18 rpm (assumed).

Therefore, to reduce the rpm, drive pulley is replaced with larger diameter pulley and decrease the diameter of traction wheel. The size of driven pulley and traction wheel is decided by calculation as given below.

$Ne \times De = Np \times Dp$ ----------eq3

Where,

Ne = no. of revolution per minute of pulley of the engine;

Np = no. of revolution per minute of pulley of transmission system;

De = dia. of pulley of engine cm; and

Dp = dia. of pulley of transmission system, cm.

$1200 \times 10 = Np \times 30$

Np = 400 rpm

Since speed ratio = 20:1

No. of revolution of traction wheel (N) = 20 rpm

The forward speed of power unit was calculated as:

Forward speed $S = \frac{\pi dN60}{1000}$ -------eq4

Where,

S = speed of power unit, km/h;

D = diameter of traction wheel, m; and

Diameter of traction wheel = 640mm.

$= \frac{3.14 \times 0.64 \times 20 \times 60}{1000} = 2.4$ km/h

Consider 10% slip, and then speed will be 2.16 km/h.

Calculate drawbar horse power (DBHP)

BHP of engine = 5 hp

DBHP = 80% of BHP

DBHP = 0.80 × 5 = 4 hp

Calculate drawbar pull

speed will be 2.46 km/h.

$DBHP = \frac{(PULL(kg) \times SPEED(m/min)}{4500}$

$Pull\ (kg) = \frac{DBHP \times 4500}{SPEED(m/min)} = \frac{(4 \times 4500)}{2500/60} = 432$ kg

Length of open belt

Length of open belt is calculated as

$= \pi \frac{(De+Dp)}{2} + \frac{(De-Dp)^2}{4c} + 2C$ ------- eq5

Where,

c = distance between center of two pulley = 36 cm

$= \pi \frac{(10+30)}{2} + \frac{(10-30)^2}{4 \times 36} + (2 \times 36) = 137.5$ cm = 140cm

Thus, a V belt of B140 is selection for transmission of power.

Determination of diameter of axle:

The axle is a rotating member which transmits power from one point to another point.

Power = 5 hp;

Rpm of the axle = 20; and

Maximum permissible shear stress = 600 kg/cm2.

$Hp = \frac{2\pi NT}{4500}$

Where,

Hp = Horse power;

N = rev. per minute; and

T = torque in kg cm.

$T = \frac{5 \times 4500}{2 \times \pi \times 20}$ = 179.04 kg m = 17904 kg cm

$T = \frac{\pi f_s d^3}{16}$

Where,

T = torque;

fs = max. Permissible shear stress; and

d = dia-meter of axle.

$d^3 = \frac{T \times 16}{\pi \times f_s} = \frac{17904 \times 16}{\pi \times 600} =$

$159.3\ m = 1.59\ cm$

d = 2 cm

Selection of V - belt and pulley

V belt drive has been selected for the design as it has following advantageous features.

Noiseless and quiet running.

No lubrication.

Acts as cushions shock.

Alignment requirements are less critical.

The v-belt drive, by slippage overcome the over loads and thus acts as a safety too.

If required, direction of shaft rotation can be easily reversed by crossing the belts.

The speed reduction is provided in three stages. In first stage engine speed reduction from 3000 to 1200 rpm by a built-in spur gear. In second stage reduction is done by means of v-belt drive between engine output shaft and gearbox input shaft and in the third stage engine gears are used to reduction speed to 20:1 gears ratio.

Selection of bearings

When there is a relative motion between two machine parts, one of which supports the other, the supporting member is called bearing. Bering plays important role in working of machine. A bearing helps a machine in many ways viz. carrying and distribution load, reduction friction to minimum, safeguard revolving, oscillating or reciprocating parts from wear due to friction etc. It helps in assembly of two parts from wear due to friction. Apart from providing support the bearing reduces friction between the moving parts, which would otherwise cause a loss of available power. Selection of bearing for farm machines is made with the following requirements.

Self – alignment often required dare to high deflections of light weight construction.

As machine has to work on soil, so adequate seals are to be used to avoid dust setting.

It should be easily available, simple in construction and low cost.

Roller bearing offers the following advantages over journal bearings

Roller bearing have an advantage where starting torque are high because of the rolling action of the balls, or rollers.

Roller bearing give warning (by becoming noisy) when failure occurs in journal bearing, the failure is sudden.

Roller bearings can take a combination of radial and thrust load.
Clearance in roller bearing need be much less than in journal bearing, providing accurate positioning of machine parts.
Roller bearing can take high over lads for short period.
In the present design, ball bearings of sizes (6206) (inner 3 cm outer dia. 6 cm) & 6506, 7205 are used and housed in ring blocks of appropriate sizes.

MATERIALS AND METHODS

The present self-propelled power unit was initially developed as power weeder for intercultural operation and later on it was further developed as multipurpose Power unit to perform secondary tillage and sowing operation. The machine is sequentially modified to full fill the need of small and medium farmers for different field operations. A new modified unit was initiated to overcome problems of existing machines and for development of output shaft which can accommodate the input shaft of different machines with the help of suitable coupling and linkages for operation of rotary unit, mower, grader etc. The self-propelled power unit is very use full and economical unit. This work of modification and fabrication was conducted in the workshop of department of Farm Machinery and Power Engineering, College of Agriculture Engineering, JNKVV, Jabalpur. The materials for fabrication of various components were selected considering requirements as given in Table 1.

Table 1. General specification after modification of self-propelled multipurpose power unit

Name of parts	Material used	Major specification
Frame and hitch	M.S. Angle & square section	50×50×5mm 50×50×5mm
Diesel engine		5hp,1200 rpm(output) air cooled diesel engine
Gear (speed reduction unit)	Spur gear Warm gear	40 teeth 8 teeth
Idler linkage system	Mild steel (flat)	Outer frame angle 50×5mm Linkage 20×3mm Idler wheel dia. 20mm
V-pulley	Cast iron	Engine shaft pulley outer dia75mm. Input gear shaft pulley outer dia. 300mm.
V-belt	Rubber fabric-cord	B (single) length 140 cm
Axle	Mild steel	Length 300 mm Dia. 25 mm
Bearing	Chrome alloy Steel ball bearing	6205 6505 7207
Bearing block	C.I.	Length 11cm Width 11cm Thickness 3cm
Acceleration wire		1m
Conduit pipe		Dia. 25 mm Length 500 mm
Output shaft	Mild steel	Length – 300 mm Dia. - 20 mm
V-pulley	Cast iron	Input outer shaft pully
Bearing	Steel ball bearing	205US
Stander finish item	Split pins, bolts and nuts	Spring washer set

Fabrication of telescopic frame

Modification in frame of the unit is urgently required to have the unit for versatile use. It must be rigid but light for easy transport. It must be strong enough to resist the sudden shocks transfer by the cutting tools. The weight must be light enough so downward load coming on the wet soil may not cause a severe sink age in kharif season. Keeping these points under consideration the square bar section of 50×50×5mm is selected as it fulfills all above requirement. Fig 2

Fabrication of hitch bar for attachment of various implement

The hitching mechanism was designed for easy attachment and better maneuverability. Various tools can be attached with the power unit by providing square box. The box was made out of hollow square bar of 40 mm sides. This square box slide forward and backward inside the hollow square section (50×50×5) of mounting frame. In the square box, circular holes (10mm dia.) are made at a regular interval of 20mm (3 hole) along the length of machine, the corresponding provision is also made in the seed drill for varying the length of hitch bar to obtain good performance at different operating depths. Fig 2

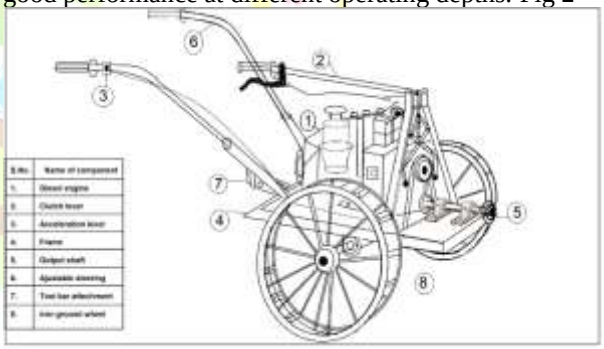


Fig 1. Schematic diagram of multipurpose power unit

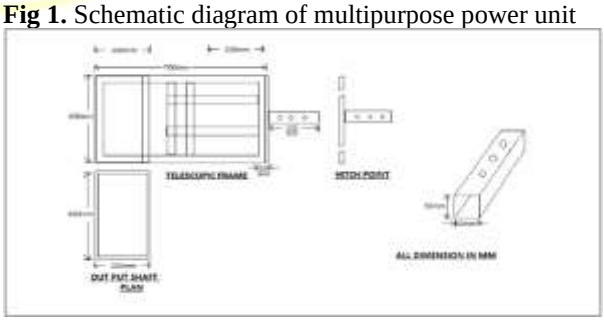


Fig. 2. Different components of telescopic frame and Hitch bar for attachment of different tools

Fabrication of output shaft and linkages

The output shaft of engine was facilitated with multi-grooves 'V' pulley. The output shaft Accommodate the input shaft of different machines with the help of suitable coupling and linkages. Mild steel round shaft of 20mm dia. and 300mm length was used for the fabrication of the axle. The axle was suitably turned on a lathe machine and finished to get accommodated in the spider bearings. The Steel ball bearing 205 Us are used in the axle. The revolution of output shaft can vary from 1000 rpm to 2000 rpm depending upon toque requirement of output reciprocating machinery.

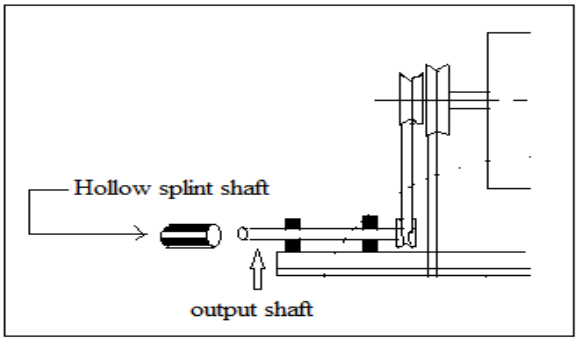
An universal joint is used to connect two shafts whose axes intersect (bevel gear) or at an angle other than the right angle to transmit rotary power from one shaft to another and to the other parallel shaft. The outer section of universal joint was attached with hollow square angle (25×25mm) and inner section of solid bar (20×20mm). The length of universal joint may vary from 400 to 700 mm depending upon the inclination of output and input shaft. The multi stage pulley mainly used to converting of RPM according to rational speed of output rotary machinery through by pulley. The drive cast iron pulley 2in, 3in, 4in, size are attached in output shaft.

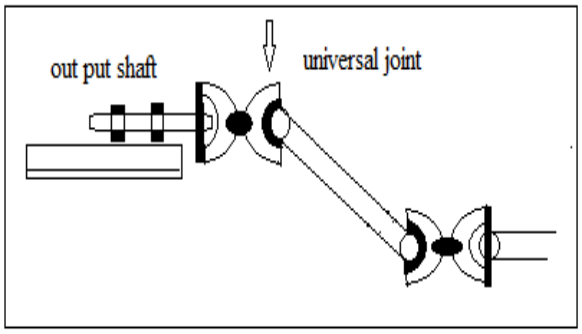
Three type of linkages provide in output shaft:-

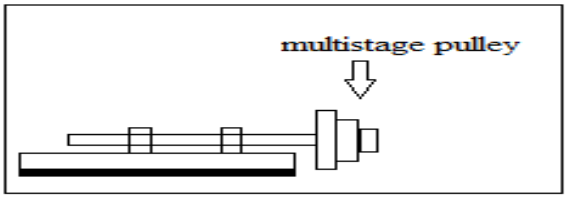
Hollow splint coupling (6 splint)

Universal joint linkage

Multistage pulley (4"in,3"in,2"in)







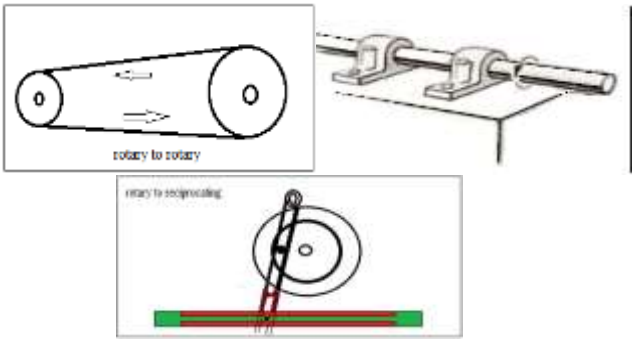


Fig. 3. Line digram of multi-stage pulley

Fabrication of Traction Wheel

Two cage wheels as traction wheel are fabricated for batter gripping and contact between wheel and soil surface, each of 640mm dia. and 80mm width, and 25mm lug height. Four mild steel flats of 2560 × 80 mm size were bent and welded to form two rims. Washers were bolted at the outer periphery it with other traction wheel. The additional wheel attached with original ground wheels are used as traction wheels in the field with lug height 25mm, lug spacing 80mm and lug angle 900. Dog clutches (Paul and ratchet) are provided at both end of axle. This helped in turning by keeping the inner wheel free. (Show in fig 4)

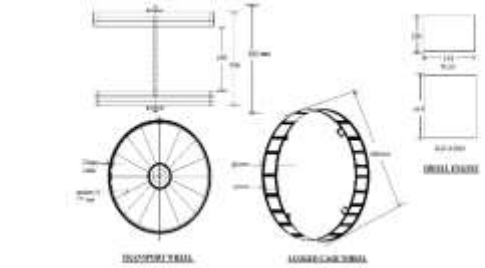


Fig. 4. Lugged Cage Wheel

Fabrication and Installation of Power Drive System

The self-propelled unit comprises of 5hp diesel engine, speed reduction unit (gear box) and V - belt pulley arrangement. These are arranged as to keep the machine balanced. The worm type gear reduction unit was located at the axle having gear reduction ratio of 20:1.

The speed reduction was done in 2 stages. First stage gave reduction of engine speed from 1200 to 400 rpm with the help of v belt pulley. The bigger pulley fitted at the end of gear box input shaft and smaller pulley fitted on output shaft of the engine. The dia. of corresponding pulleys are 30 cm and 10 cm respectively. These pulleys were connected to a V-belt of size B 46. Second stage reduction was in the worm gear reduction unit. The output shaft of gear was extended in both sides and used as the axle for the traction wheels. Two V-pulleys, one V-belt and two idler pulley linkage system was used to transmit the power from engine to the traction wheels. One U clamp of flat mild steel was fabricated and arranged in such a manner so that it could move on driven idler pulley touching its surface of the V-belt. It

was used for increases the angle of contact on the idler pulley and maintains the desired tension as the belt stretches for engaging and disengaging power transmission unit. The detail construction of clutch system is given in fig 5. The outer linkage flat iron of size made of MS angle 40×4mm according to width and thick are used. The vertical bar was connected to horizontal bar with the help of nut and bolts and fixed on frame. The clutch lever was made of 20mm dia. and 50 cm length. Clutch lever was fitted along with the help of spring. Under the normal condition, both idler remained in engaging position due to spring pressure and the power transmission through from driven pulley to tight the belt and rotation of one causes rotation of the other output shaft of the gear reduction unit. When the clutch handle was push down, the u clamp at the engaged idler with belt and disengaged the power supplied from engine output shaft. The linkage clutch was brought back to the engaged position by bringing back the handle to its normal position.

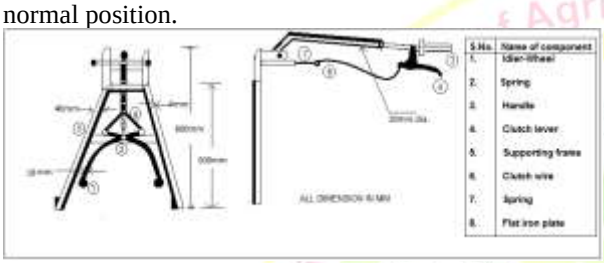


Fig. 5. Line diagram of power engaging and disengaging system

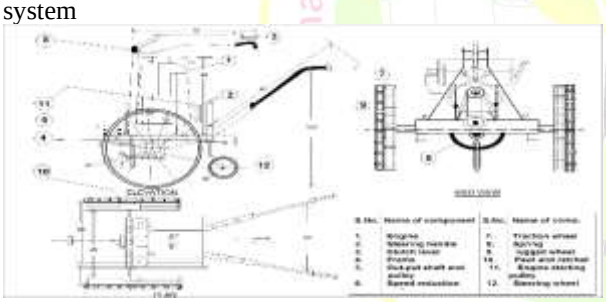


Fig. 6. Schematic diagram of multipurpose power unit

Vibration Isolators

Vibration levels depend on the terrain conditions and engine speed of the machine. It was observed that as the engine speed increases, RMS (root mean square) value of vibration also increases and it was highest on the top surface of the engine followed by the chassis, seat, handle, base of handle bar end gear box. The vibration at the top of the engine was the highest since the major reason of the vibration of the machine is the unbalanced inertia force of the engine. Four vibration isolators were mounted between the engine and chassis. With this, excitation of the unbalanced inertia force of the engine gets transmitted to the chassis through the isomer only because of the high percentage of molecular diffusions in the case of rubber isomer, the mechanical energy would be consumed and dissipated as heat, and the instantaneous vibration would be attenuated rapidly. 25 mm thick isolator was placed between two metal plates. Dimension of isolator (60 x 60 x 25) mm.

Measurement of the effective noise level

Recording instrumentation

Instruments used in this study were: METRAVI SL-4005 sound level meter with sound level: Lo = 35-100 db or Hi = 35-135 and the flat frequency, weighting 6.0, time weighting slow or fast. Response in human threshold of hearing range sound level meters with 20 - 146 dB dynamic range and 0.1 dB accuracy.

Location of measurement point

The Policies normally specify noise limits for outdoor areas of noise sensitive areas. It is therefore preferable to choose a point outdoors to take measurements. It should be chosen so a maximum level of the noise source is obtained.

Microphone placement

The test site was prepared and maintained according to ISO (ISO 5131, 1996) and SAE (SAE J1174, 1985) sound measurement standards.

The test area are free from obstacles and consisted of a flat open space free from the microphone is holding 1.2 m above the ground surface and 5 m away from the center of the power unit in (Fig-7) path way in a horizontal position and pointed in the direction of travel. The background noise was at least 30 dB lower than that for the power unit.

Equipment checkpoints

When measurements of noise are being made in the field, (from a factory premises, entertainment noise or background noise) certain procedures should be employed to ensure an accurate measurement is obtained. Some of these procedures also apply to analysis of tape-recordings in the farm.

Some pieces of equipment require a minimum 'warm-up' time before their performance is optimum. The manufacturers' recommendations are the best guide.

A battery was being checked in the field before and after it is used.

A calibration check was made both before and after the measurement. Calibration checks varied slightly, but variation was not significant.

The picker was operated at the recommended travel speed 2.5 km/hr of prime mover at full accelerator. The test is observed in three stage ideal rpm, rated rpm, maximum rpm to accelerated by lever adjusting (1200, 1500 and 1800 rpm) of the engine.

Noise at By-Stander Position

The measurement of the noise of power unit at bystander position shall be conducted in accordance with (ISO 5131, 1996):

The measurement was made with the power tiller stationary on a soil surface,

The engine of the power unit operated at the manufacturer’s rated speed and all mechanisms shall be functioned as in normal field work.

The weighted sound pressure level was measured and reported

Fig. 6. Sound level meter (Digital)

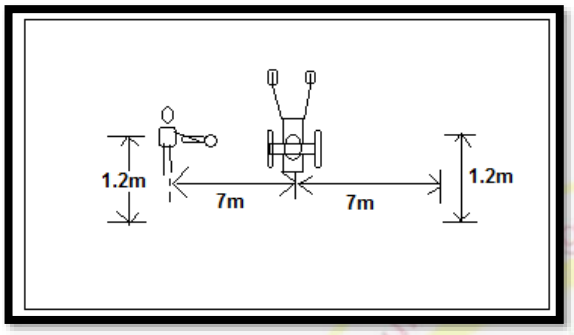


Fig.7. Dimensions of the measurement area

Measurement of the effective vibration

The experiment was conducted to evaluate the performance of vibration of multipurpose power unit implemented in the College of Agriculture Engineering. We have used ACD – D 83 instrument to measure the vibration for developed power unit to check it is suitable or not as for operator handle structure, causes increased vibration at operating knobs. Proper insulation between engine and handle reduces the vibration greatly when transmitted to hands. The use of hand tractors in farmlands and countryside where the terrain has plenty of roughness is one of the main sources of increased vibration.

Description vibration meter modal ACD – D 83

All machines with rotating/moving parts or carrying currents vibrate. The maximum life and performance can only be achieved by operating machines within these specified limits.

The vibration meter is primarily to suit the above purpose. The regular measurement of various machines can be taken to judge their mechanical status. The instrument can be used for very wide range of measurements. It can measure 0 to 2000 microns DISPLACEMENT in the range of 600 R.P.M to 60,000 R.P.M.

The displacement of mechanical vibration of components/assemblies of the power unit measured with the help of suitable vibration measuring instrument on the components of machines.

The power unit shall be parked on a level soil surface. The power engine is started optimum rpm is adjusted, rated rpm and maximum rpm of engine and its operated at rated engine speed at load and no-load position of power unit. The maximum horizontal displacement (HD) and vertical displacement (VD) in microns shall be measured by mounting the measuring device in relevent positions.

The data shall be recorded in accordance with vibration meter.

Fig.7. Vibration meter

Drive wheel skid

The travel distance of the ground drives wheel in a given no. of revolutions increases due to skidding of the wheel. It is the difference between ideal distance a wheel should move and the distance actually moved by the wheel.

$$\text{Slippage (\%)} = \frac{N_1 - N_2}{N_1} \times 100$$

N_1, N_2 Distance covered with & without attachment respectively.

RESULTS AND DISCUSSION

This study deals with the study related to modification of existing self-propelled multipurpose power unit machine and the performance evaluation of developed output rotary shaft to operate various machinery and provide attachment of tillage tool bar for tillage operation under laboratory and actual field condition. It also contains the cost economics. The utility of the same machine may vary with the land holding. The machine can be used for 1000 to 1500 hour per year. A larger farmer can handle larger area. This small walking type tractor costing low may equally usable to the large farmers.

Identification of problems in existing machine and development of a modified power unit

In existing power unit, the alignment of frame was improper and it was fixed type. The MS angle size was 40 ×40×5 mm. This frame size was not suitable to bear the load of machine with attachment of tool bar and cutting tool for tillage. The reason of this was its rigidity which was not adjustable according to arrangement of another tool carrier. The handle was not adjustable for 5th to 95th percentile operator.

To eliminate this problem in the power unit a telescopic type frame is provided which also supported the end of output shaft with the help of fixed bearing housing. Bearing also reduced the vibration in the machine and

kept shaft in such a way so axis of rotating is fixed. This MS angle 50 × 50 × 5 is used in the modified frame to bear the load and bending moment coming on frame. This is suitable for operating for 5th to 95th percentile operator the adjustable, height of handle is 1 m to 1.3 m from ground surface.

Fig 9. Alignment of frame in (A) existing model (B) modified model

Fig. 10. Handle height for 5th to 95th percentile operator

Power engages and disengages system:

The power from engine output shaft is transmitted to input shaft of gear reduction unit through belt. In existing power unit single idler pulley was mounted on the frame which moved a lever up and down by cable and bar to tight and slack the v-belt on pulley. There was the friction between belt and pulley resulting to high temperature and sticking of belt due to release problem. This system did not work effectively and when it was disengaged by lever power transmission was not completely disconnected. To eliminate this problem modified power transmission system was developed and the system engage and disengage become easy due to reduction in quantity of linkages resulted into less effort and more contact area cause reduction of slippage and heat generation in the belt. Now this system is working proper with less effort. Two idler pulley are used which resulted in to more contact area thus less heat generation between belt and pulley.

Fig. 11. Arrangement of power engaging & disengaging (A) existing (B) modified

Modification for better traction wheel

In existing unit iron wheels with 640mm diameter 83 mm wide was used inverted triangular shape lugs were used for easy transportation on the road. During tillage operation when power unit operated in the field the iron wheel did not provided proper grip between lugs & soil surface. Many time it skid over clods which caused instability of machine caused side wise turning. To eliminate this problem new traction cage wheel was designed and developed. The dimensions of new developed cage wheels were 640mm diameter, 80mm lugs spacing 25 mm lug height & lug angle 900. This cage wheel is attached to outer rim periphery of existing iron wheel with nut and bolts. This resulted in increased traction (increased grip between track and terrain) caused reduced slip in wet soil and reduced skid on clods increased to a great extent because of fact that contact is between wheel and soil increased caused better side wise stability.

Fig. 12. View of Traction cage wheel (A) existing (B) modified

Table 2. Observation on wheel slippage before and after attachment of additional lugged cage wheel

Theoretical distance covered in 10 rev. (m)	Actual distance covered in 10 rev. (m)	Existing unit Slippage (%)	Modified unit Slippage (%)
20.10	16.7	17	5
20.10	16	20	6
20.10	15.8	21	5
20.10	17	15	5
Average	16.3	20	6

The tractive efficiency of existing machine was 68 % that needed to be increased. This machine had high fuel consumption due to low field efficiency caused by more slippage; the average slippage value was 13.6 % at 14 % soil moisture content on dry basis. The tillage tool bar device was driven by traction wheel that was the reason of uneven tilling of implement. The average percentage of slip in power unit without lugged cage wheel was 20% and with attachment of developed lug cage wheel was reduced to 6% in (Table-2), the 6% slip is the permissible limit as per the test code 6183. The developed cage wheel also increased the field capacity 0.08 ha/hr. So developed lug cage wheel also increased the traction and proper griping between iron wheel and contract soil surface.

Development of different component of multipurpose power unit

Front output shaft:

Developed multipurpose power unit is a versatile power unit which can be used for field preparation, sowing and with the application of power on front output shaft operations like Inter culture operation, water pumping, mower & harvesting and winnowing/threshing in small agricultural fields could also be achieved easily the demonstration of this power unit among farmers visiting the college fascinated them to due to its reliability and versatility. The machine is sequentially modified to full fill the need of small and medium farmers for different operations. A new modification unit would be initiated to overcome problems of existing machines and developed output shaft which can accommodate with the input shaft of different machines with the help of suitable coupling and linkages to operate rotary machinery, mower, grader etc. The existing power unit was used only for sowing purpose and the provision for attachment of various implement was limited. In newly developed self-propelled multipurpose power unit various Implement can be attached easily to the chassis with the help of rectangular box type hitching mechanism and also can operate output rotary machinery for other inter culture operation.

Table 3. Linkages used for different operation

Operation	Linkages used
Water pumping	Universal joint
Winnower	V-belt pulley
Mower	V-belt pulley & axle
Sowing	Adjustable Hitch bar
Tillage	Tool frame hitch bar

Use of vibration isolator:

The vibration and noise in existing unit was high that caused drudgery to the operator and required regular maintenance. In modified developed power unit vibration isolator are provided in between engine and chassis to reduce the vibration and noise shown in fig (13). and measurement vibration in farm of displacement through by vibration meter shown reading in table (7 and 8) and noise level in db shown reading in table (5 and 6).

Noise measurement

The experimental value of noise measurement exposures of the developed self-propelled multipurpose power unit operators was measured during load and without load operations. Table-4 shows some information according to Occupational safety & health administration, USA has given a standard (OSHA, 1983) for occupational noise exposure. It mentions that the permissible daily (8-h) exposure to the operator is to be up to 90 db.

Table 4. Permissible daily noise exposure as per OSHA - 1983

Duration per day, hours	Sound level, (db)
8	90
6	92
4	95
3	97
2	100
1.5	102
1.0	105
0.5	110
0.25	115

Table 5. Noise measurement without load condition

Engine rpm	Noise level in (db)	Permissible limit
1200	74	90
1500	79	90
1800	86	90

Procedure to apply for noise measurement was according to Indian standard test code value shown in, Table 5.4 and Table 5. The (IS 12207: 1999) recommends that maximum ambient noise at operator's ear level should not exceed 90 db for continuous working of 8 hr. The obtained value of noise measurement reading of power unit is suitable for farmer's body during 8 hr working time.

Vibration measurement

The experimental value of vibration measurement of the developed self-propelled multipurpose power unit operators was measured during load and without load operations. The vibration was recorded by vibration meter, reading show in displacement (µm). The engine rpm are adjusted by tachometer. The purpose of this measurement was to assess exposure to hand-arm vibration in power unit operator. The hand-arm vibration measurement was done according to the standards ISO 5349-1 and ISO 5349-2. The obtained results indicated that the exposure level in three dimensions X, Y and Z consecutively result show that vibrations were the same in all three measurements. Measurements were performed on a vibrating surface as close as possible to the grip center of power unit handle and chassis. Vibration assessment was done according to ISO 5349 standard.

Displacement (µm) of vibration in three directions x y and z

Total hand-arm handle and chassis vibration: The actual test results of average total hand-arm and chassis

vibration in load and without load operating of power unit users are in Table 7 and Table 8.

Evaluation of vibration: The value of vibration is specified in the relevant standards. Whole body vibration is evaluated by calibrated graph chart of ISO 2954-1975 value in displacement (µm) exposure limit of safe limit of whole-body vibration ranges. According to (IS 12207:1999)

Steering handle – 100 – 150 µm.

Chassis – 200- 300 µm.

Table 7. Vibration (in µm) measurement without load (standing) condition

Mode	Engine rpm	Measurement direction	Vibration in chassis (µm)	Vibration in handle (µm)	Permissible value ISO 2954-1975 In (µm)
Idle rpm	1200	X Y Z	226 230 227	153 156 155	Very Good 100 -150
Rated rpm	1500	X Y Z	217 219 217	130 133 128	Good 150 -200
Maximum rpm	1800	X Y Z	198 202 198	126 127 118	Slightly rough 200 - 400

Table 8. Vibration (in µm) measurement with load (movable speed 2.5 km/hr) condition

Mode	Engine rpm	Measurement direction	Vibration in chassis (µm)	Vibration in handle (µm)	Permissible value ISO 2954-1975 In (µm)
Idle rpm	1200	X Y Z	217 219 217	130 133 128	Very Good 100 -150
Rated rpm	1500	X Y Z	198 202 198	126 127 118	Good 150 -200
Maximum rpm	1800	X Y Z	197 198 193	121 123 115	Slightly rough 200 - 400

CONCLUSION

On the basis of above it can be concluded that the 5hp self-propelled power unit developed under the project is a low-cost power unit which can efficiently be used for various tractive and stationary work and such power unit is found to be most useful prime mover for small and medium farmers. Due to the change of power engaging system and reduction of linkages reduced the operator's drudgery. Due to the use of additional wheel the traction is improved under the wet land soil condition and on ploughed land having higher number of clods. Due to the use of isolator the vibration remains with the permissible level. This power unit can be used for variety of operation that too where ever it is needed.

As there is no complex component so it can be assembled and fabricated even by the local artisans.

Fig. 13. By-stander test for noise

Fig. 14. Vibration measurement at standing position

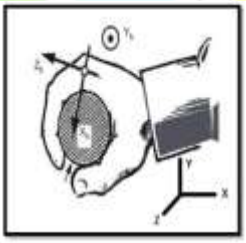


Fig 15 Axes of the acceleration components

Fig 16 Directions X, Y and Z in this study

Fig 17 Vibration in handle

Fig 18 Vibration in chassis

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Research Article

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Diversity and distribution of spiders from Tenkasi district, India

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ABSTRACT
Biodiversity can be simply defined as the variety of all types of living organism. Spiders are among the most diverge groups on earth, which received the seventh ranking in global diversity after the sixth largest insect orders. Spiders are major playing a vital role in the forest ecosystem is the spiders. The spotted spider specimens were taken photographed identified without disturbing it. A total of 17 species of spiders under 15 genera and 9 families were recorded during the Four months survey in five falls in Coutrallam, Tenkasi district, Tamilnadu state, India.
Keywords: Spider, Arachnida, Biological control, Diversity.

INTRODUCTION

As one of the most widely recognized group of arthropods, spiders make up a diverse portion of the world's invertebrates (Coddington, J.A *et al* 1991).They are distributed on every continent except Antarctica and have adapted Spiders are clearly an integral part of the global biodiversity since they play an important role in ecosystems as predators and source of food for other creatures (Sharma S *et al* 2010).They primarily feed on insects, but also eat other arthropods, including other Araneae. They are suitable biological indicators of ecosystem changes and habitat modifications due to their small body size, short generation time, and high sensitivity to temperature and moisture changes (Kremen, C et al 1991).

Spiders form the seventh largest animal order in ter ms of numbers of known species and are common predatory arthropods in all terrestrial and many aqu atic ecosystems. This is the most diverse, female-dominated and entirely predatory order in the arthropod world. Spiders are key components of all ecosystems in which they live and are considered to be useful indicat ors of the overall species richns andhealth of terrestrial communities. However, spiders of the Western Ghats ar e a poorly explored group and detailed information ab out their systematic, diversity and ecology in this ' biodiversity hotspot' is scarce.

Spider has also an important role in the ecosystem maintenance. They are considered as the prospective biological control agents (Riechert and Bishop, 1990). They feed on small insect and in turn eaten by birds and other carnivores maintaining the trophic balance of nature.

Araneae is the largest entirely carnivorous group of animals on the planet. Researchers have described over 75,000 species of arachnids worldwide with many more undescribed. Spider diversity, distribution and insectivorous feeding habits are suspected of playing an important role in the balance of nature (Oyeniyi Abiola Oyewole, 2014). Globally, the loss and degradation of natural habitats results in the loss of biodiversity (Foelix, 1996). This may disrupt ecosystem functions and constitute a major threat to the long-term biodiversity conservation.

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Taxonomic studies of different spider species from wildlife sanctuaries, paddy fields and cotton fields were investigated by many researchers (Vungsilabutr, 1988; Sahu et al., 1996; Patal, 2003; Mathirajan and Raghubathy, 2003; Vanitha et al., 2009; Bhatkar, 2011;

Chetia and Kalita, 2012). The present study aimed to carry out survey of the spider fauna in the five falls in Coutrallam,Tenkasi District,Tamilandu State,India. It is the first approach in this region, to study the spider fauna, thus providing base line information for future studies.

MATERIALS AND METHODS

Study Area

The spiders were observed from photographs taken in Coutrallam Falls (8°55′55″N 77°16′09″E / 8.93194°N), Tenkasi district, Tamilnadu..It is located in Western Ghats to the South of Coutrallam town and to the north of Coutrallam Lower.

Identification of spiders

The diversity and density of spiders throughout the study period was investigated by the hand picking method from December 2020 to March 2021. The spotted spider specimens were photographed in the same environment without disturbing it. All specimens were identified using the taxonomic keys for Indian spiders given by Tikader (1987); Biswas and Biswas (1992) and Sebastian and Peter (2009).

RESULTS AND DISCUSSION

Spider diversity, distribution and their insect feeding habits play an important role in the balance of nature (Yong and Edward, 1990). They are potential biological indicators of natural habitats and are used for determining how communities react to environmental changes or disturbances (Marc and Canard, 1997). The status of spider diversity is an important constraint to evaluate the community level of biological organization. Higher species diversity is an indicator of a healthier and complex community because a greater variety of species allows more interactions, hence greater system stability which in turn indicates good environmental conditions (Hill, 1973).

The results show that there are 17 species of spiders, 15 genera and 9 families found. The abundance and the number of family species that are mostly found is Araneidae (5 species), followed by Salticidae (4 species), followed by Thomisidae (2 species), followed by the family of Cheiracanthiidae, Pholcidae Sicariidae, Oxyopidae, Gnaphosidae, Theridiidae, are each family one species recorded (Table 1 and figure 2). Ambily and Antony (2016) reported total 40 species of spiders belonging to 14 families from Kerala. Among all families, Araneidae was most dominant family followed by Salticidae.

Under the present study Araneidae was the most dominant family comprising of seven genera and 16 species with 33.33 per cent species distribution. This may be more or less in accordance with the earlier work. Further, More (2015) from Maharashtra also recorded Araneidae as one of the most dominant family, thus closely support the present findings. In the present investigation, a total of 48 species of agrobiont spiders in 34 genera belonging to 12 families were recorded and the pictorial checklist of different agrobiont spiders from the study area was prepared (J.N. Prajapati et al,2018).

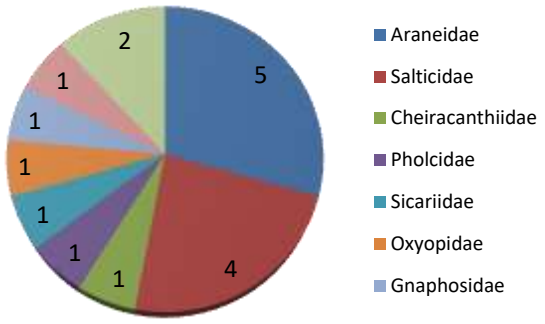

Figure 1. Species distribution in different families found in five falls in Couttrallam,Tenkasi District, Tamilnadu State, India

Table1. Spider species recorded during the study

Family	genus	species
Araneidae	*Argiope*	*Argiope argentata (Fabricius, 1775)*
Araneidae	*Argiope*	*Argiope bruennichi (Scopoli, 1772)*
Araneidae	*Argiope*	*Argiope pulchella (Thorell, 1881)*
Araneidae	*Gasteracantha*	*Gasteracantha geminata (Fabricius, 1798)*
Araneidae	*Nephila*	*Nephila pilipes (Fabricius, 1793)*
Salticidae	*Colonus*	*Colonus sylvanus (Hentz, 1846)*
Salticidae	*Hasarius*	*Hasarius adansoni (Audouin, 1826)*
Sicariidae	*Loxosceles*	*Loxosceles rufescens (Dufour, 1820)*
Salticidae	*Menemerus*	*Menemerus bivittatus (Dufour, 1831)*
Salticidae	*Plexippus*	*Plexippus paykulli (Audouin, 1826)*
Thomisidae	*Thomisus*	*Thomisus spectabilis (Doleschall, 1859)*
Thomisidae	*Misumena*	*Misumena vatia (Clerck, 1757)*
Cheiracanthiidae	*Cheiracanthium*	*Cheiracanthium mildei (L. Koch, 1864)*
Pholcidae	*Crossopriza*	*Crossopriza lyoni (Blackwall, 1867)*
Gnaphosidae	*Scotophaeus*	*Scotophaeus blackwalli (Thorell, 1871)*
Theridiidae	*Steatoda*	*Steatoda nobilis (Thorell, 1875)*
Oxyopidae	*Peucetia*	*Peucetia viridans (Hentz, 1832)*

Some previous studies reported similar kind of findings. Quasin (2011) reported Araneidae as the dominant family (18%) followed by Salticidae and Thomisidae (11.5%), Theridiidae (8.6%), Linyphiidae (7.4%), Uloboridae and Tetragnathidae (4.5%), and Gnaphosidae, Oxyopidae, Sparassidae and Lycosidae (4.1%) in Nanda Devi Biosphere Reserve, Dehradun, Uttarakhand. On the other hand, some studies also reported Salticidae as the dominant family. Kazim et al (2014) reported family Salticidae as the most common family that represents the highest species diversity while Araneidae is second largest in species diversity and rest of the families has equal quantity. Deshmukh and Raut (2014) also found Salticidae as the most abundant

(19.23%) followed by Aranidae (18.26%), Thomisidae (12.05%), Oxyopidae (8.65%), Lycosidae (7.69%), Gnaphosidae (6.73%), Philodromidae (4.76%), Eresidae (3.84%), Tetragnathidae (3.84%), Pholcidae (2.88%), Th eridiidae (2.88%), Clubionidae (1.92%) and Uloboridae (1.92%). The least species diversity was recorded in the families of Hersilidae, Miturgidae, Nephilidae, Scytodidae and Sparacidae with 0.96% in each family. Study conducted in Jahangirnagar University campus at Bangladesh also reported Salticidae as the dominant family (Rain et al., 2016).

The checklist of the Araneae of different countries/continents/ecozones were published in recent past by several authors, like Gajbe (2003), Dandria *et al*., (2005), Siliwal *et al.,* (2005), Namkung *et al.,* (2009), Ursani and Soomro (2010), Khan (2011), Perveen and Jamal (2012), Sial *et al.,* (2012), Adarsh and Nameer (2015), Lawania and Trigunayat 2015), Perveen and Khan (2015), Adarsh and Nameer (2016), Ghazanfar *et al.,* (2016) and Prajapati *et al.,* (2016).

CONCLUSION

This was the first attempt to document spider diversity in Five falls in Southern India. The diversity at ecosystem level supports large number spiders in the Coutrallam area. Since the study area is a human dominated landscape, they are facing threats like habitat loss, pollution and changes in land use pattern. Appropriate conservation strategies should be developed and implemented to conserve the faunal and floral diversity of the region.

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Research Article

OPEN ACCESS

Suitability of Eucalyptus Clones in Eastern Gangetic Plains of Uttar Pradesh, India- A Case Study in the Raebareily District, India

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ABSTRACT
In India, Eucalyptus is one of the prime species in Agroforestry and farmers are mostly diverting towards clonal planting material of this species for more returns in a shorter rotation period. Eucalyptus is among the most widely cultivated forest trees in the world over 22 million hectares. Eucalyptus *hybrid* and *E. tereticornis* are the two most widely planted Eucalyptus trees in India. The area under agroforestry in India is estimated as 25.32 million ha (Mha), or 8.2 per cent of the total geographical area of the country. A total of 53.32 Mha, representing about 17.57 per cent of the total reported geographical area (TRGA) of India, could potentially be under agroforestry in the near future, thus making agroforestry a major land-use activity, after agriculture and forestry. In the recent past, clonal forestry had played a significant role in producing better production yield in a shorter time. It is also well established that the performance of Eucalyptus clones is superior over normal seed-borne plants. Therefore, there is an urgent need for improvement in the production of forest resources to meet the needs of fuel-wood, timber and wood production on a sustainable basis and increase biomass yield from farm forestry plantations. Thus, the main objective of this study was to assess the growth performance of Eucalyptus clones in the Gangetic plains of Eastern Uttar Pradesh in the Raebareily district for the identification of suitable planting material. The trial was conducted under the statistical design of Complete Randomized Blocks with 3 replicates and 3 x 2 m spacing for all 19 clones of Pragati Biotech, Punjab (413,07,526, 04, K-25, 288, 2013, 2023, 2070, 2136, 3018, 2031, P-13, P-14, P-23, P-32, P-45, P-50, P-66) of 03 eucalyptus species (*E. hybrid*, *E. tereticornis and E. camaldulensis*) along with control for all 20 treatments in respective districts. Based on growth performance parameters such as height, girth, diameter, basal area and tree volume, overall clones- P-13, P-50, P-23, 526, P-32, 3018 and P-45 performed superior over other treatments in the Raebareily district. Here, all well-performing clones of the Punjab series belonged to *E. camaldulensis* only whereas 3018 is *E. hybrid.* This study has clearly shown that the selection of clones for a particular site is very important to get maximum productivity of clonal eucalypt plantations in and around Eastern Uttar Pradesh.
Keywords: Clonal Eucalyptus, suitability, growth attributes, agroforestry, promising clones.

INTRODUCTION

Many wood-based industries have started to raise large-scale *Eucalyptus* plantations as it provides a variety of uses such as timber, construction boles, firewood, honey, pulp, and paper. *Eucalyptus* can withstand salinity, drought and waterlogging conditions and also acts as recreational areas, windbreaks, shelterbelts etc. (Sandhu *et al.* 2020; Silva *et al.* 2014). Eucalyptus plantations can also improve degraded lands by stabilizing soils, improving soil nutrient status and increasing soil organic matter through the enhancement of above-ground litter production (Lugo & Waide 2013). In India, Eucalyptus is one of the prime species in Agroforestry and farmers are mostly diverting towards clonal planting material of this species for more returns in a shorter rotation period. Eucalyptus is among the most widely cultivated forest trees in the world over 22 million hectares (Nichols *et al.* 2010). Among five important trees outside forests in the state of Uttar Pradesh, the relative abundance per cent of Eucalyptus trees in rural areas is 15.86 and in an urban area, it is 8.87 (FSI, 2019). Vijayaraghavan and Sivakumar (2017) stated that Eucalyptus *hybrid* and *E. tereticornis* are the two most widely planted Eucalyptus trees in India. Many species can tolerate flooding or swamp lands and are given vernacular names e.g. flooded gum (*E. grandis*), swamp gums (*E. camphora* and *E. ovate*), river red gum (*E. camaldulensis*) and swamp mahogany (*E. robusta*). The area under agroforestry in India is estimated as 25.32 million ha (Mha), or 8.2 per cent of the total geographical area of the country. A total of 53.32 Mha, representing about 17.57 per cent of the total reported geographical area (TRGA) of India, could potentially be under agroforestry in the near future, thus making agroforestry a major land-use activity, after agriculture and forestry (Dhyani *et al.*

2012). In recent past, clonal forestry had played a significant role in producing better production yield in shorter time. It is also well established that performance of Eucalyptus clones is superior over normal seed borne plants. Therefore, there is an urgent need for improvement in the production of forest resources to meet the needs of fuel-wood, timber and wood production on a sustainable basis and increase biomass yield from farm forestry plantations. (Patil *et al.* 2012).

Large-scale Eucalyptus plantations have been raised on forest & farmlands, community lands and road/rail/canal strips in India. These plantations have created a very useful resource for timber, poles, pulpwood and fuel wood. However, most of these past plantations had very large genetic variation, low productivity ranging from 6 to 10 m3. ha-1. yr-1 and poor returns because inferior seeds were used for raising most of the target-oriented plantations (Lal, 1993). As a short rotation and fast-growing nature, Eucalyptus is widely preferred by farmers for pulp and paper industries as well as in the local market for pole (Behera, 2016). In the eastern part of Uttar Pradesh state of India, Eucalypts are in the improving stage for adoption at a larger level and the choice of suitable clones in plantations is still a big challenge for them. Thus, the main objective of this study was to assess the growth performance of Eucalyptus clones in the Gangetic plains of Eastern Uttar Pradesh in the Raebareily district for identification of suitable planting material in the region.

MATERIALS AND METHODS

Study Area

The district Raebareily forms a part of the Lucknow Division. It lies between 25°49' to 26°36' North latitudes and 100°41' to 81°34' East longitudes. It covers an area of 4,609 sq. km, and is home to 3,404,004 people. On the North, it is bounded by tehsil Mohanlal ganj of district Lucknow and tehsil Haider gargh of district Barabanki, on the east by tehsil Mussafir Khana of district Sultanpur and the south east by pargana Ateha and the Kunda tehsil of district Pratap Gargh. The southern boundary is formed by the Ganga which separates it from the district of Fatehpur. On the west lies the purwa tehsil of district Unnao. The district, as a whole, is fairly compact tract of gently undulating land. The elevation varies from about 120.4 m. above sea level in the north west to 86.9 m. above sea level in the extreme south east, on the banks of the Ganga. The highest points are the crowns of the watersheds of the different drainage channel which serve to divide the district into five main physical units, The ganga Khadar, the ganag upland, the southern clay tract, the central tract or the sai upland and the Northern clay tracts. The district forms a part of the Gangetic plan which is of recent origin according to geological chronology and reveals ordinary gangetic alluvium. The district is a part of the alluvial plain confirm the same geological sequence as the plain itself. The only mineral of importance is kankar. The district is also noted for its deposits of reh and brick earth.

About the 13th century the greater part of the district was covered with extensive forests. During the period of second world war and thereafter, forest in the district were recklessly cut down. The areas of such land already planted with trees like dhak, khair, babul, shishum, neem, vilayti babul, arjuna, kanji, siras, eucalyptus, mango and Jamun are 544 hectares in tehsil Raebareily, 500 hectares in tehsil salon, 348 hectares in tehsil Dalmau and 61 hectares in tahsil Maharajganj. The climate of the Raebareily district is almost dry. Annual rainfall is about 900-1000 m.m. which is mainly from July to September. Paddy is the main Kharif crop and Wheat is the main Rabi crop in the district. Sugarcane and potato are the main cash crops of the district. Before Independence Production of paddy and wheat was 5 Quintal and 4 Quintal Per hectare respectively (Census of India 2011).

Map of district Raebareli

Establishment of experimental trial

This district lies under the Eastern Gangetic plains of Eastern Uttar Pradesh. This trial was established in the year 2016 with 19 Punjab clones in the village of Habirapur. It is a small Village/hamlet in Deeh Block in the Raebareily District of Uttar Pradesh State. It is located 52 km from the district headquarters of Raebareily, and 130 km from the State capital Lucknow. The trial was conducted under the statistical design of Complete Randomized Blocks with 3 replicates and 3 x 2 m spacing for all 19 clones of Pragati Biotech, Punjab (413,07,526, 04, K-25, 288, 2013, 2023, 2070, 2136, 3018, 2031, P-13, P-14, P-23, P-32, P-45, P-50, P-66) of 03 eucalyptus species (*E. hybrid, E. tereticornis and E. camaldulensis*) along with control for all 20 treatments. The mixture of 100g of NPK (3:2:1) fertilizer and FYM (1.0 kg per plant) were applied at onset of monsoon during planting to assist establishment of growth. The irrigation was also done twice a month normally and in hot summers once in a week. The annual increment of each clone was calculated using all the growth parameters (girth at breast height; gbh and height) for consecutive five years. The basal area in m^2 (BA =0.00007854 x DBH in cm) and volume of trees in cum ($V= \pi r^2 x h$) / tree (r and h in m), (1667 trees / ha in 3x2 spacing) were also calculated (Larsen, 1999). The data analysed statistically by standard ANOVA technique

using RBD. The statistical analysis was done by data analysis tool package of OPSTAT prepared by Statistical Software Package for Agricultural Research Workers. CCS HAU, Hisar, Haryana (Sheoran *et al*. 1998).
The details of clones are as following:

S. No.	Clone No	species name
1	P13	*E. camaldulensis*
2	2136	*E. camaldulensis*
3	P50	*E. camaldulensis*
4	P23	*E. camaldulensis*
5	526	*E. camaldulensis*
6	P66	*E. camaldulensis*
7	2070	*E. camaldulensis*
8	288	*E. tereticornis*
9	2023	*E. camaldulensis*
10	P32	*E. camaldulensis*
11	413	*E. camaldulensis*
12	P14	*E. camaldulensis*
13	3018	*E. hybrid*
14	K25	*E. camaldulensis*
15	2021	*E. camaldulensis*
16	07	*E. tereticornis*
17	P45	*E. camaldulensis*
18	2013	*E. camaldulensis*
19	04	*E. camaldulensis*

RESULTS AND DISCUSSION

The results for evaluation of the growth performance of these clones were recorded for annual increment in measurements of total height (m) and girth at basal height; gbh (cm) for five years and are depicted in Table 1 & 2; Fig.1 & 2. The highest value of increment in gbh belonged to clones P-13 (49.04 cm) followed by P-50 (46.16 cm), P-23 (45.68 cm), 526 (44.01 cm), P- 32 (43.13 cm), 3018 (42.89 cm) and P-45 (41.91). The lowest values belonged to clone 2013 and P-66 with 32.73 and 33.26 cm respectively. The clones with good annual increment in height were P-13 (20.15 m) followed by P-50 (20.14 m). The performance of the control clone was inferior for girth and height increments as compared to the clone series. The remaining clones had different ranks of gbh and height increments as compared to the control. The results of the analysis of variance for annual mean increments in height and girth showed in Tables 1 & 2. In Fig. 3, performance scores were assigned to well-performing clones based on their increments in girth and height after five years of planting. The basal area and tree volume were also calculated for clones and were superior for higher-scored clones with their respective values of girth and height increments after five years of planting (Table 3, Fig. 4 & 5). Based on growth performance parameters such as height, girth, diameter, basal area and tree volume, the clones, P-13, P-50, P-23, 526, P-32, 3018 and P-45 performed superior over other treatments in the Raebareily district. Here, all well-performing clones of the Punjab series belonged to *E. camaldulensis* only whereas clone 3018 is *E. hybrid.*

Table 1. Annual increment in height (m) in five years of planting

Clones	year 1	year 2	year 3	year 4	year 5
P-50	0.45	3.83	10.12	15.53	20.14
413	0.46	4.2	8.58	13.19	17.16
288	0.35	2.29	9.96	15.74	17.26
2023	0.44	3.42	8.67	13.9	17.5
P-45	0.44	3.08	11.06	17.3	18.83
3021	0.42	3.67	7.56	11.88	16.44
P-14	0.32	2.45	7.33	12.53	16.34
2013	0.32	2.23	6.78	10.01	13.99
P-66	0.41	3.28	6.97	11.46	14.9
3018	0.43	3.11	9.2	14.55	18.38
P-32	0.36	2.38	7.98	13.8	17.93
2070	0.45	3.71	8.94	14.56	17.74
P-23	0.33	1.6	9.72	15.51	19.27
07	0.38	2.59	8.9	14.8	18.66
K-25	0.36	2.48	7.75	13.55	16.81
2136	0.43	3.71	8.17	14.23	18.26
P-13	0.31	1.62	5.91	10.27	20.15
526	0.37	2.14	9.09	15.1	18.67
04	0.34	1.89	7.54	13.15	17.17
Control	0.33	1.39	7.19	11.87	13.64
C.D. (5%)	0.08	1.06	1.55	2.39	1.88
SE(m)	0.03	0.37	0.55	0.84	0.66
SE(d)	0.04	0.53	0.77	1.19	0.94
C.V.	14.92	27.13	13.09	12.35	7.65

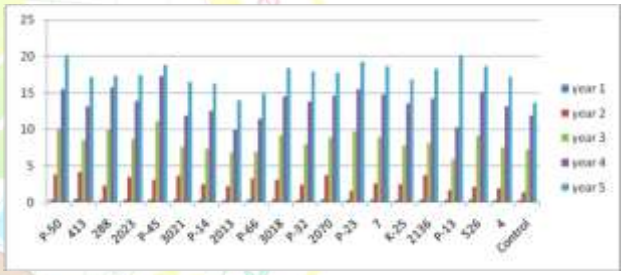

Fig.1. Annual increment in height (m) in five years of planting

The variation among clones in growth parameter may be due to genetic makeup and interactions with environmental factors. Similarly, Dhillon and Singh (2010) also found a difference in diameter growth among clones of *E. tereticornis* at the age of 3.5 years. Lal *et al* (2006) identified the best clones out of 36 *viz*., clone 2070, 285, 316, 288, 498, 286 and 2045 for Punjab's ecological condition. Luna and Singh (2009) studied the growth performance of 12 clones of Eucalyptus at Ludhiana. Clone no. 413 and 2070 recorded significantly higher height growth as compared to other clones. In south Gujrat, clonal variation for growth parameters such as DBH, mid-diameter, height, form quotient and volume were significantly different among 20 clones of Eucalyptus and DBH varied between 11.47 and 16.07 cm with an overall mean of 13.28 cm (Behera,2016). The clones have to be tested in target environments before deploying in plantations (Oballa *et al*. 2005).

Table 2. Annual increments in girth (cm) after five years of planting

Clones	year 1	year 2	year 3	year 4	year 5
P-50	0.91	6.26	21.56	35.49	46.16
413	1.05	6.06	19.16	32.34	36.25
288	0.88	3.64	19.03	32.83	37.01
2023	0.98	4.56	15.91	27.54	37.19
P-45	1.06	5.83	22.18	37.01	41.91
3021	0.83	6.38	14.7	24.84	35.5
P-14	0.63	6.34	13.44	23.04	37.66
2013	0.69	3.76	10.09	25.89	32.73
P-66	0.73	4.84	12.03	20.05	33.26
3018	0.94	4.85	17.58	27.03	42.89
P-32	0.75	4.55	16.71	26.43	43.13
2070	0.91	6.01	19.49	32.54	34.14
P-23	0.8	2.79	17.91	32.74	45.68
07	0.79	3.78	23.31	40.38	36.43
K-25	0.78	4.69	18.7	31.55	37.56
2136	0.63	4.88	15.01	27.04	37.64
P-13	0.66	3.6	11.96	22.94	49.04
526	0.79	3.53	19.13	33.99	44.01
04	0.89	4.48	15.95	26.69	35.59
Control	0.86	2.51	13.85	23.86	29.35
C.D.(5%)	0.20	N/A	4.90	7.40	9.61
SE(m)	0.07	1.06	1.73	2.60	3.35
SE(d)	0.10	1.50	2.44	3.68	4.73
C.V.	16.88	45.60	20.52	18.14	14.64

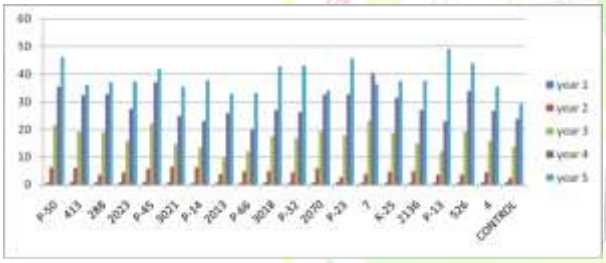

Fig. 2. Annual increment in girth (cm) after five years of planting

The fact that most clones outperformed the provenance seed lots at comparatively waterlogged conditions (Karaikkal); whereas some clones were inferior to the best provenance seed lot demonstrates that clonal selections should not be transferred to contrasting environments without thorough testing (Vijayaraghavan *et al*., 2016). Red Gum (*Eucalyptus camaldulensis* L.) is renowned globally for its fast growth, high levels of drought tolerance and adaptability to diverse climatic conditions and soils, which makes it popular among eucalypt tree growers (Bindumadhava *et al*. 2011). Kumar and Bangawa (2006) observed significant differences in growth attributes among seven species of *Eucalyptus* species. It is also established *E. camaldulensis* is a pure species adapted to low-to intermediate rainfall environments with a dry season of up to 8 months. Several studies have reported the significant growth performance of Eucalypt clones in the world. The results of the study confirm that clones of *E. camaldulensis* are well adaptable in the Gangetic plain region of the Raebareily district of Uttar Pradesh in India.

Table 3. Performance of clones for basal area and tree volume

Clone / Treatment	Height (m)	Girth (cm)	DBH (cm)	Basal area /tree (sq m)	Volume /tree (cu m)
P-50	20.14	46.16	14.70	0.0012	0.34167
413	17.16	36.25	11.54	0.0009	0.17953
288	17.26	37.01	11.79	0.0009	0.18823
2023	17.5	37.19	11.84	0.0009	0.19271
P-45	18.83	41.91	13.35	0.0010	0.26333
3021	16.44	35.5	11.31	0.0009	0.16496
P-14	16.34	37.66	11.99	0.0009	0.18451
2013	13.99	30.73	9.79	0.0008	0.10518
P-66	14.9	33.26	10.59	0.0008	0.13123
3018	18.38	42.89	13.66	0.0011	0.26920
P-32	17.93	43.13	13.74	0.0011	0.26555
2070	17.74	34.14	10.87	0.0009	0.16462
P-23	19.27	45.68	14.55	0.0011	0.32014
O7	18.66	36.43	11.60	0.0009	0.19717
K-25	16.81	37.56	11.96	0.0009	0.18881
2136	18.26	37.64	11.99	0.0009	0.20597
P-13	20.15	49.04	15.62	0.0012	0.38582
526	18.67	44.01	14.02	0.0011	0.28791
04	17.17	35.59	11.33	0.0009	0.17316
Control	13.64	31.35	9.98	0.0008	0.10673

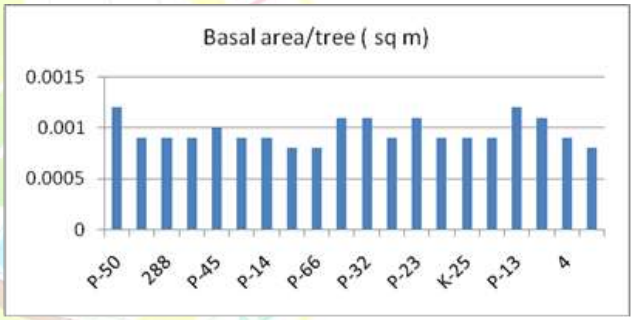

Fig 4. Basal area /tree (sq/m)

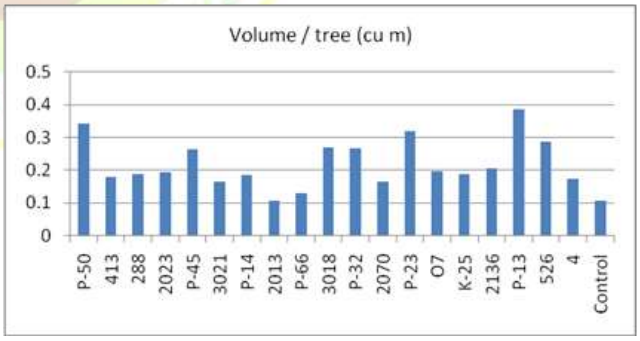

Fig. 5. Volume /tree (cu m)

CONCLUSION

It is clear from the study that the selection of clones for a particular site is very important to get maximum productivity of clonal eucalypts plantations in and around Eastern Uttar Pradesh. In addition, this study demonstrated that there would be clear benefits, concerning the productivity of a large eucalypt plantation to pursuing site-specific selection and deployment strategies for the highly productive clones.

Although implementing such a strategy could require significant investments in field trials, for larger growers with plantations spread across site types, the benefits concerning increased clonal plantation with site-specific clones would be more beneficial. Therefore, clonal plantations of Eucalyptus under an agro-forestry system should be encouraged and integrated with the planned development of wood-based industries through innovative policy changes. Extension services must be strengthened for taking the research findings from lab to land and maximizing the benefits of the vast potential of clonal technology for the society and farmers of our country. Thus, suitable clones of eucalypts may improve agroforestry in the region of eastern UP.

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